Air Force Institute of Technology

Catalog of the Graduate School of Engineering and Management

Academic Year 2001 - 2002

The Graduate Catalog represents the offerings, programs, and requirements in effect at the time of publication, but there is no guarantee that they will not be changed or revoked. The course offerings and requirements of the institution are continually under examination and revision. However, adequate and reasonable notice will be given to students affected by any change. This catalog is not intended to state contractual terms and should not be regarded as a contract between the student and the institution. The institution reserves the right to change any provision, offering, or requirement to be effective when determined by the institution. These changes will govern current and readmitted students. Enrollment of all students is subject to these conditions.

Graduate students must assume full responsibility for knowledge of rules and regulations of the Graduate School of Engineering and Management and the departmental requirements for their chosen degree program. Any exceptions to Graduate School policy stated in this catalog must be approved by the Dean of the Graduate School of Engineering and Management. Individual departments may have requirements beyond the minimum established by the Graduate School. Students are referred to the academic departments for the most current requirements of a program.

ACADEMIC CALENDAR

ACADEMIC YEAR
2001 - 2002

2001 Fall Short Term
20 – 29 Aug 2001 – Winter 2002 Pre-Registration Period
21 Aug - Report No Later Than Date for Military Students
22 Aug - 3 Sep - Student Orientation and In-processing
27 Aug - 7 Sep - New Student Registration for Fall 2001 and Winter 2002 Terms
3 Sep - Labor Day Holiday
4 Sep - Technical Refresher Courses Begin
24 Sep – 12 Oct - Fall Quarter Open Registration
28 Sep - Technical Refresher Courses End

2001 Fall Quarter
1 Oct - Classes Begin
8 Oct - Columbus Day Holiday
12 Oct - Last day to Register for Fall Quarter
12 Oct – Last day to withdraw without record from Fall Quarter courses
2 Nov – Last day to withdraw with record of W from Fall Quarter courses
12 Nov - Veterans' Day Holiday
26 Nov – 5 Dec - Spring 2002 Pre-Registration Period
22-23 Nov - Thanksgiving Holiday
7 Dec - Classes End
10 Dec – 18 Jan - Winter Quarter 2002 Open Registration Period
10-14 Dec - Final Exams

2002 Winter Quarter
3 Jan - Classes Begin
18 Jan – Last Day to Register for Winter Quarter
18 Jan – Last day to withdraw without record from Winter Quarter courses
8 Feb - Last day to withdraw with record of W from Winter Quarter courses
21 Jan - Martin Luther King Day Holiday
18 Feb - Presidents' Day Holiday
4 Mar –13 Mar – Summer 2002 Pre-Registration Period
15 Mar - Classes End
18 Mar – 12 April - Spring 2002 Open Registration Period
18-22 Mar - Final Exams
26 Mar - Graduation

2002 Spring Quarter
1 Apr - Classes Begin
12 Apr – Last Day to Register for Spring Quarter
12 Apr – Last day to withdraw without record from Spring Quarter courses
3 May – Last day to withdraw with record of W from Spring Quarter courses
27 May - Memorial Day Holiday
28 May – 5 Jun – Fall 2002 Pre-Registration Period
7 Jun - Classes End
10 June – 12 July - Summer 2002 Open Registration Period

10-14 Jun - Final Exams
28 Jun – Air Mobility Program Graduation

2002 Summer Quarter
1 Jul - Classes Begin
4 Jul - Independence Day Holiday
12 Jul – Last Day to Register for Summer Quarter
12 July – Last day to withdraw without record from Summer Quarter courses
2 Aug – Last day to withdraw with record of W from Summer Quarter Courses
26 Aug – 4 Sep - Winter Quarter 2003 Pre-Registration Period
2 Sep - Labor Day Holiday
9 Sep – 18 Oct – Fall 2002 Open Registration Period
6 Sep - Classes End
9-13 Sep - Final Exams

CONTENTS

1 GENERAL

History of AFIT

The Air Force Institute of Technology (AFIT) traces its roots to the early days of powered flight when it was apparent that the progress of military aviation depended upon special education in this new science. Before 1919, aviation officers were educated at the Massachusetts Institute of Technology. Then, in 1919, the Air School of Application was established at McCook Field in Dayton, Ohio, the home of Orville and Wilbur Wright. When Congress authorized creation of the Air Corps in 1926, the School was renamed the Air Corps Engineering School and moved, along with all the operations at McCook field, to Wright Field in 1927. Shortly after Pearl Harbor, the school suspended classes, but reopened as the Army Air Forces Engineering School in 1944 to conduct a series of accelerated courses to meet emergency requirements.

After World War II, in 1946, the Army Air Forces Institute of Technology was established as part of the Air Materiel Command and was composed of two colleges: Engineering and Maintenance, and Logistics and Procurement. These colleges were later redesignated the College of Engineering Sciences and the College of Industrial Administration. When the Air Force became a separate service in 1947, the Institute was renamed the Air Force Institute of Technology. That same year, the Air Installation Engineering Special Staff Officer's Course began. In 1948, responsibility for managing officers attending civilian institutions was transferred to the Air Force Institute of Technology.

In 1950, command jurisdiction of the Institute shifted from Air Materiel Command to Air University with headquarters at Maxwell Air Force Base, Alabama. The Institute, however, remained at what is now known as Wright-Patterson Air Force Base. In 1951, the two Air Force Institute of Technology colleges were combined into the Resident College. The Institute established a logistics education program at Wright-Patterson Air Force Base in 1955, and The Ohio State University conducted the first courses on a contract basis. In 1958, the Air Force Institute of Technology began a series of short courses in logistics as part of the Air Force Logistics Command Education Center. Later that year, the School of Logistics became a permanent part of the Air Force Institute of Technology.

In 1954, the 83d Congress authorized the Commander, Air University, to confer degrees, upon accreditation by a nationally recognized association or authority, to persons who met all requirements for those degrees in the Air Force Institute of Technology Resident College. In October 1954, the Engineering Council for Professional Development accredited the undergraduate Aeronautical and Electrical Engineering curricula and the first degrees were awarded in 1956. The American Assembly of Collegiate Schools of Business accredited the Institute's business program in May 1958, and the first Master of Business Administration degrees were awarded that year. The School of Business was closed in 1960 after granting 383 Master's degrees.

In April 1960, the North Central Association of Colleges and Schools accredited the Institute as a Master's degree-granting institution and this accreditation was extended to the School of Logistics in 1963. In 1965, the Institute received preliminary accreditation, at the doctoral level, from the North Central Association and that accreditation became final in 1972. Since granting its first degree in 1956, the Institute has awarded more than 14,000 degrees.

In 1963, the School of Logistics was re-designated the School of Systems and Logistics. The Civil Engineering Center was also re-designated as the Civil Engineering School.

Over the next 30 years, the Institute's organization changed little, but it continued to grow and respond to the changing needs of the Air Force. New programs were developed and others were terminated. As an example, the Institute granted its last baccalaureate degree in 1985. In 1992, the Institute reorganized from three to four resident schools by specifically removing all graduate programs from the School of Systems and Logistics and establishing a new school, the Graduate School of Logistics and Acquisition Management. On October 1, 1999, the Graduate School of Logistics and Acquisition Management and the Graduate School of Engineering were combined to become the Graduate School of Engineering and Management.

In 1995, the Air Force Institute of Technology established its first program to be offered at a distant location. The Air Mobility Program, taught at Fort Dix, New Jersey, is a yearlong program designed to provide officers assigned to the Air Mobility Command the opportunity to further their education in a course of instruction specifically designed to enhance their expertise as operational airlift logistics experts. The first class of 10 students entered in the spring of 1995 and graduated the following May. The program utilizes facilities located at Fort Dix, New Jersey, located adjacent to McGuire Air Force Base, home of Air Mobility Command's east coast operations center. Institute instructors travel to the Fort Dix site to teach these courses.

The Institute has long been an active participant in the larger educational community. In 1967, the Air Force Institute of Technology became a member of the Dayton Miami Consortium, which later changed its name to Southwestern Ohio Council for Higher Education. The Council is an association of colleges, universities, and industrial organizations in the Dayton area, which are united to promote educational advancement. The Institute has traditionally been active in both the council and in other community and inter-institutional programs. In 1995, the Air Force Institute of Technology joined with two other local institutions, Wright State University and the University of Dayton, to form a consortium called the Dayton Area Graduate Studies Institute. This consortium's purpose is to coordinate, integrate, and leverage the resources of the three schools to improve and expand graduate-level educational opportunities in the engineering disciplines. This consortium has since expanded by adding The Ohio State University and the University of Cincinnati as affiliate members. The Ohio Board of Regents, the educational governing board for the State of Ohio, funds the consortium to provide scholarships for graduate engineering students at the three local institutions. In addition, the Board of Regents provides state funds to encourage collaborative research in support of the Air Force Research Laboratory at Wright-Patterson Air Force Base. Through this program, teams of researchers from the consortium schools are funded to perform research, which supports that laboratory.

As the Air Force Institute of Technology begins its ninth decade of operation, faculty and staff members reflect with pride on the contributions the Institute's graduates have made to engineering, science, technology, medicine, logistics, and management. These immeasurable contributions have been vital to national security. The future promises to be even more challenging than the past, and the Air Force Institute of Technology is prepared to continue providing the environment and the opportunity for Air Force personnel to develop the professional and technological skills needed to master this dynamic challenge.

Mission

The mission of the Graduate School of Engineering and Management is to produce graduates and engage in research activities that enable the Air Force to maintain its scientific and technological dominance.

The school's mission reflects its focus on preparing students with the skills required to maintain the world's best Air Force, with the recognition of research as a critical element in quality graduate education.

The Graduate School of Engineering and Management provides scientific, technological, and management education applicable to Air Force, Department of Defense, and civilian research and development environments. The Graduate School not only enhances the intellectual growth of its students by offering a broad range of high-quality graduate programs, but also prepares them for successful careers in engineering, applied science, and management. In the preparation of its curricula and in its operation, the Graduate School is continually cognizant of its unique responsibility – the technical and management education of Air Force officers so they can fulfill their roles in serving their country to the greatest degree possible. The Graduate School must also expect and support the continuing scholarly and creative activity of its faculty members, for the benefit such activity brings to instruction, and for the benefit it brings to the enlargement of human knowledge, understanding, and appreciation.

The Graduate School has as its primary responsibilities instruction and research, but it also must contribute to the wider community. Its endeavors include service to the local community, the greater Air Force and aerospace community, and the community of technical, scientific, and managerial professionals. These service activities are performed through active involvement in professional and local organizations at the local and national levels, local community volunteer functions, and Air Force community service activities.

Accreditation

The Air Force Institute of Technology is accredited by The Higher Learning Commission and is a member of the North Central Association (NCA). The NCA can be contacted at:

The Higher Learning Commission
NCA
30 North LaSalle Street, Suite 2400
Chicago, Illinois 60602-2504
Phone: (800) 621-7400

In addition to institutional accreditation, the Accreditation Board for Engineering and Technology (ABET) accredits selected engineering programs within the Graduate School of Engineering and Management. These curricula are Aeronautical Engineering, Astronautical Engineering, Computer Engineering, Electrical Engineering, Nuclear Engineering, and Systems Engineering. ABET can be contacted at:

Accreditation Board for Engineering and Technology, Inc.
111 Market Pl., Suite 1050
Baltimore, MD 21202
Phone: (410) 347-7700
Fax: (410) 625-2238

Organization

The Graduate School of Engineering and Management offers graduate programs leading to Master of Science and Doctor of Philosophy degrees in engineering, applied science, and management disciplines. It is responsible for (1) all academic and admission policies as developed and approved by the faculty council, (2) the development of new programs, and (3) maintaining the appropriate standards for graduate-level programs. The administrative services of the school are provided by the Dean's Office, which is composed of the Dean and the Associate Dean of the Graduate School, the Associate Dean for Research, and the Assistant Dean for Academic Affairs.

Six academic departments within the Graduate School deliver the graduate programs. These departments are Aeronautics and Astronautics, Electrical and Computer Engineering, Engineering Physics, Mathematics and Statistics, Operational Sciences, and Systems and Engineering Management. Each department is responsible for the development and operation of its laboratories at all levels of activity; for the content and teaching of its academic courses; and the conduct of research programs. The chief administrative officer of each department is the department head, who reports directly to the Dean of the Graduate School of Engineering and Management.

Board of Visitors

The Air Force Institute of Technology (AFIT) Board of Visitors (BOV) is comprised of a select group of eminent educators from prominent US colleges and universities and senior executives from major industries. The Board serves in an advisory capacity and meets annually. Its purpose is to review and evaluate AFIT policies related to accreditation, admission requirements, curricula, instructional methodology, facilities, management, and other aspects of AFIT. The Board of Visitors presents its findings and recommendations in a written report to the AFIT Commandant. The report is included in the annual report submitted by the Air University Board of Visitors to the Commander, Air University and is reviewed by Headquarters United States Air Force.

The following individuals comprise the current membership of the BOV.

General Michael P. C. Carns, USAF, Retired (Chair)
President and Executive Director
Center for International Political Economy
New York, NY

Lieutenant General Thomas R. Ferguson
USAF Retired
Former Senior Partner, Dayton Aerospace, Inc.
Dayton, OH

Dr. Earl Dowell
J. Jones Professor of Engineering
School of Engineering
Duke University
Durham, NC

Dr. Thomas E. Cooper
Vice President, General Electric Company
Washington, DC

Dr. Norman Thagard
Professor and Director of College Relations
Florida A&M University, Florida State University
Tallahassee, FL

Dr. Dennis P. Slevin
Professor of Business Administration
The Katz Graduate School of Business
University of Pittsburgh
Pittsburgh, PA

Dr. Michael Bragg
Dept Head and Professor of Aeronautical and Astronautical Engineering
University of Illinois
Urbana, IL

Degrees Offered

The degrees currently available through the faculty of the Graduate School of Engineering and Management are a Master of Science (MS), Master of Science in (Engineering Discipline) for ABET accredited programs, Master of Air Mobility, and Doctor of Philosophy (Ph.D.). The MS programs are listed below, and those fields of study that are starred indicate the areas in which Ph.D. programs exist. ABET-accredited programs are also identified.

Acquisition Management
*Aeronautical Engineering (ABET)
Aerospace and Information Operations
*Applied Mathematics
*Applied Physics
*Astronautical Engineering (ABET)
*Computer Engineering (ABET)
Computer Science
Computer Systems
Cost Analysis
*Electrical Engineering (ABET)
*Electro-Optics
Engineering and Environmental Management
Environmental Science and Engineering
Information Resource Management
Information Systems Management
Logistics Management
*Materials Science
Meteorology
*Nuclear Engineering (ABET)
*Operations Research
Space Operations
Systems Engineering (ABET)

Further Information

The Graduate School of Engineering and Management publishes several documents annually that provide detailed information about the Graduate School's programs, degree requirements, and research activities.

Each academic department maintains a departmental brochure, a publication that describes the details of that department's programs. This publication provides officers assigned to AFIT on a full-time basis with a proposed "program plan." This program plan (i.e., program of study) specifies the quarter-by-quarter requirements for each program offered by the particular department, including details of each area of specialization, suggested options for fulfilling the mathematics requirements, and any special information about each program. The brochure also informs students who are not officer-students about program requirements. These brochures can be obtained by contacting the individual departments.

The Office of Research and Consulting (ENR) publishes a research report, documenting student and faculty research activity, sponsored program support, and research assessment questionnaire results. This report is routinely distributed to research sponsors and potential collaborators. Copies can be obtained upon request by contacting the ENR via any of the following ways:

Mailing address:
AFIT/ENR
2950 P Street
Wright-Patterson AFB, OH 45433-7765

E-mail address:
afit.enrsta@afit.edu

Internet address:
http://en.afit.edu/enr/

GENERAL

The Graduate Catalog provides the general information about the degree requirements, academic programs, and academic policies of the Graduate School of Engineering and Management. Additional copies of this catalog can be obtained by contacting:

Office of the Registrar
AFIT/RRD
2950 P Street
Wright-Patterson AFB,
OH 45433-7765
Telephone: (937) 255-2791/DSN 785-2791

General and detailed information about the Graduate School and its departments and programs are found at the following Internet address: http://www.afit.edu.

2 ADMISSIONS

General Information

Students must be officially accepted for admission into the Graduate School of Engineering and Management before they may register for graduate courses. Individuals holding a Bachelor's Degree from an accredited college or university in a discipline appropriate to academic programs in the Graduate School are eligible for admission. Applicants must have adequate undergraduate preparation in their proposed field of study and must show promise for satisfactorily pursuing studies at the graduate level. Programs offered by the Graduate School of Engineering and Management are available to officers of all branches of the United States Armed Services, U.S. Government civilian employees, non-Government U.S. citizens, civilians who hold permanent resident status, and officers/government employed civilians from select foreign countries.

Inquiries for admission and requests for application forms should be addressed to the Admissions Office, AFIT/RRE, 2950 P Street, Wright-Patterson Air Force Base, Ohio 45433-7765 or on the World Wide Web at http://afit.edu/admissions. The Admissions Office may also be contacted at 1-800-211-5097.

The application procedures for military officers who wish to attend a graduate program as a full-time student differ from those of other potential students. Therefore, officers from all branches of the United States Armed Services must consult their respective organizations about the application procedures for attending AFIT's Graduate School of Engineering and Management. The Admissions Office can also provide the detailed information.

Applications for admissions and all supporting documentation for officers who wish to attend on a part-time basis and civilians who plan to enroll in courses in either a part-time or full-time status should be received at least four weeks before registration for the quarter in which the student wishes to begin graduate study.

International officers interested in applying must contact the International Affairs Division to determine eligibility. Contact AFIT/IA at (937) 255-6800 ext 3116.

Upon admission, students are designated as full time or part time by the institution. Graduate students who are not officers assigned to AFIT are also classified according to their relationship to formal programs, as follows:

1. Regular Status – The student is admitted as fully qualified to pursue a program leading toward a graduate degree. That is, the student has met all the general requirements of the institution and the specific program requirements of the department in which the student plans to pursue study.

2. Conditional Status – The student must fulfill some prerequisite imposed by the Graduate School or department before admission to regular status; also, the student whose preparation cannot be yet determined is assigned conditional status. Generally, the terms for regular admission must be satisfied prior to the start of the next academic quarter. Otherwise, the student will not be allowed to register for further course work.

3. Non-Degree Status – The student who belongs to either of the following categories:

- The student will not be officially enrolled in a graduate program leading to a degree;

- The student fulfills all the requirements and is taking courses for credit but is not seeking a degree.

Admission to the Graduate School of Engineering and Management does not necessarily constitute admission into candidacy for an advanced degree. Such candidacy is subject to specific requirements as defined by the individual programs.

Admission Requirements

1. Complete an application form;
2. Submit one official transcript from all colleges/universities previously attended. Transcripts must be sent directly to the Admissions Office;
3. Admission into all M.S. programs requires an earned baccalaureate degree from an accredited college or university in an appropriate discipline, an overall undergraduate grade point average (GPA) of at least 3.00, and Graduate Record Exam (GRE) scores of at least 500 (verbal) test and 600 (quantitative). Graduate Management Admissions Test (GMAT) scores of at least 550 may be submitted in place of the GRE for certain programs offered in the Department of Systems and Engineering Management and the Department of Operational Sciences.
4. Admission to a doctoral program requires a master's degree in an appropriate discipline with a minimum graduate GPA of 3.50, and minimum Graduate Record Exam scores of 550 (verbal) and 650 (quantitative);
5. International officers must also submit Test of English as a Foreign Language (TOEFL) scores in addition to meeting the above requirements.

Individual departments may have additional or alternative admission requirements for specific programs. Each department may grant waivers to certain admission criteria on an individual basis. The student is responsible for providing all the necessary information and supporting documentation. Otherwise, the graduate student will not be allowed to register for courses. Applicants should contact the appropriate department for further information.

3 FINANCIAL INFORMATION

Students assigned to the Graduate School of Engineering and Management by the U.S. Air Force and other military organizations to pursue degrees full time incur no financial liability with regards to tuition.

All other students are responsible for all their financial obligations including tuition. The tuition for Department of Defense (DoD) employees is $185 per quarter hour for 1 - 11 credit hours and $2175 per quarter for a full-time student (12 or more credit hours). Non-DoD employees are charged tuition at $310 per credit hour for 1- 11 credit hours or $3720 per quarter for a full-time student. (NOTE: These tuition rates are subject to change each year and are available upon request from AFIT/RPB, Bldg 643, Room 216, 2950 P. Street, Wright-Patterson AFB, Ohio 45433-7765 or by phone at 937-255-8400, Extensions: 3615, 3616, 3619, or 3621.)

Scholarships and stipends are available through the Dayton Area Graduate Studies Institute (DAGSI). Full tuition scholarships ($14,880/year) and stipends ($15,000/year for PhD students) are available as well as scholarships for part-time students seeking a degree. Application forms can be obtained from either the AFIT Admissions Office or by downloading the application form at www.DAGSI.org. The Graduate School of Engineering and Management should receive all application materials from each DAGSI scholarship applicant before 1 March to ensure full consideration for a fall program start. Scholarship applications cannot be considered until students have completed the admissions process.

Additional financial support is available through Research Assistantships (RA), depending upon academic program, research interests and availability of sponsor funds. Student research assistants may be hired as temporary, part-time U.S. Government employees, usually at 20 hours/week. The RA salary ranges from approximately $19,000 per year for first-year master's students to $23,500 per year for advanced Ph.D. students. Further information may be obtained from the Office of Research and Consulting or the academic department office. The Office of Research and Consulting can be contacted at:

AFIT/ENR
2950 P Street
Wright-Patterson AFB, OH 45433-7765

E-mail address: afit.enrsta@afit.edu
Phone: (937) 255-3633

4 RESOURCES

AFIT Academic Library

The primary mission of the library is to provide comprehensive standard library services in support of the core instructional, research, and consultation requirements of the Institute's faculty, students, and academic staff.

The Academic Library is housed in a central, modern 40,000 sq. ft. facility. The library is open to the public from 7:30a.m. – 9:00p.m., Monday through Thursday, 7:30a.m. – 5:00p.m., Friday, and 11:00a.m. – 6:00p.m. Saturday and Sunday. A faculty reserve reading room is available to all faculty members for setting aside select materials relating to their respective courses. The facility also features 12 student seminar rooms and two conference rooms. In addition, a new computer classroom and laboratory with 17 workstations is available to library patrons.

In the aggregate, library collections number more than a million items. The book collection is primarily made up of titles that support the subject areas of management, engineering, physics, procurement, computer science, mathematics, aviation, and military science. The journal collection is comprised of more than 2000 foreign and domestic titles covering the social, basic, and applied sciences, and the collection is being updated to add hundreds of additional journal titles in the electronic format. A comprehensive collection of conference reports, journals, and transactions are available to library users. The Library receives select series of Air Force technical reports as well as reports from the Army, the Navy, the National Aeronautics and Space Administration, the Air Force National Guard, the Rand Corporation, and other agencies. These reports are available in paper and microform and represent the largest segment of library holdings. The Library also holds a comprehensive collection of the Institute's resident graduate students' theses and dissertations. A small, circulating collection of non-print media is also available to the library's patrons. This collection is made up of audiovisual materials, which include videos and audiocassettes, as well as microforms in support of the mission of the Institute. The Reference collection contains standard and specialized reference works for engineering and logistics, and also includes strong bibliographical collections for the identification of research materials that are not held by the Library. Such materials may be obtained on interlibrary loan (ILL) from national and regional cooperating libraries and bibliographic centers. Finally, various material relating to the Institute's history, including annual histories, accreditation reports, inspection reports and other special reports dating back to 1919, are held in the archival collection.

AFIT maintains literature-searching tools that are critical to the research needs of the faculty, staff, and students. These tools include the Air University Library Index to Military Periodicals, the Aerospace Database, Defense Technical Information Center database, ABI/Inform, INSPEC, FirstSearch, COMPENDEX PLUS, NASA/RECON and Environmental Abstracts, which are available on the Web or on compact disks in the library. In addition to the above-mentioned end-user services, the library provides librarian-mediated searches to numerous commercial and governmental databases through DIALOG, which has several hundred databases containing millions of records which provide bibliographic information to books, technical reports, newspapers, journal and magazine articles, patents and statistical data and other online vendors. Descriptive information is available on millions of books, journal articles, conference proceedings, films, software, and various other reports. There is no charge to students or faculty members for these fee-based services.

Orientation programs and instructional classes are provided to students and faculty throughout the year, so that they can make more effective use of library resources.

The Institute's library is a member of the Southwestern Ohio Council for Higher Education. With valid identification, all registered Institute faculty members and students may borrow directly from most council members' libraries. Wright State University and the University of Dayton have the area's largest academic libraries, and provide Institute faculty members and full-time graduate students with direct borrowing privileges. Furthermore, the library is a member of the Online Computer Library Center, an online bibliographic and interlibrary loan provider that enables the identification and retrieval of library and research materials locally, nationally, and internationally.

Computer Resources

The Air Force Institute of Technology's Directorate of Communications and Information (SC) provides a broad range of information resources and services to the students, faculty, and staff of the Institute. SC provides the support for research and instructional clients, and a staff of consultants is available to provide support and expertise in a variety of areas. Services provided by the directorate include network and communications, central and end-user computing support, information systems planning and support, customer support, applications development, visual information, and administration. Further information can be found on SC's web site at http://www.afit.edu/support/sc_home.htm.

AFIT/SC establishes computer accounts for every enrolled graduate student, and each faculty and staff member. This account enables use of electronic mail (e-mail), software application access, information and database storage and retrieval, network access, homework, class assignments, and other similar functions. Accounts are to be used for Institute-related and official government business only by the person assigned the account. Most graduate students will automatically be assigned a computer account through SC's coordination with the Directorate of Admissions/Registrar. If you have not been automatically assigned a computer account, you'll need to submit a request to the Computer Customer Support Center, through your faculty advisor.

The Institute's computing capabilities include a variety of mathematical, statistical, simulation, and modeling applications available on Silicon Graphics, Inc. (SGI), Sun Microsystems, and Intel-based platforms. There is also a wide array of programming languages for use while completing class projects, assignments, theses, and research projects. Over 250 workstations throughout the Institute provide access to these applications and programming languages.

In addition to the scientific workstations, AFIT also maintains over 1,300 Pentium and notebook computer systems for general office automation functions such as e-mail, word processing, spreadsheet, database, and presentation software. Assistance and problem resolution are available through SC's Computer Customer Support Center during normal duty hours.

Internet access options are abundant. In addition to global e-mail capability, the Institute offers Internet and World Wide Web browsing applications, File Transfer Protocol, News Reader service, and Telnet. These access options are available on either Unix/Linux workstations or PCs. The Internet is a valuable resource for students and faculty alike while performing research.

SC offers a central computer classroom/research lab in Building 642, Room 2202. Here, customers can log onto one of over 20 high-performance, dual-processor PCs to access any of the applications mentioned above. High-speed black-and-white and color laser printers for hard-copy output are readily available for coursework and thesis production. Finally, AFIT/SC provides resources for producing compact discs as a means to archive theses and other projects.

SC's clients can also access many of AFIT's computing capabilities from off-campus using Wright-Patterson AFB's dial-in modems or via a Virtual Private Networking session through an Internet service provider. Our remote access capabilities permit access to private data storage areas, e-mail, the Internet, and other services. You can also access your voice mail messages from home or while traveling.

AFIT is a member of the Ohio Higher Education Computing Council (OHECC) and the Ohio Academic Research Network (OARNET). Through these affiliations, AFIT/SC provides customer access to The Ohio State University's supercomputer center. Students and faculty also have access, through AFIT's network, to the supercomputing facilities at Wright-Patterson AFB's Major Shared Resource Center (MSRC).

AFIT Student Association

The AFIT Student Association (ASA) is a student-run organization whose goal is to provide a conduit through which student concerns can be raised to the Dean's office, as well as promote the welfare of the student body. Each year, the incoming class elects representatives from their class to serve as the ASA staff. They work closely with the senior staff at AFIT to ensure students' voices are heard. In addition, ASA provides a number of services for the student body. ASA negotiates with venders to put together a discounted software package containing applications students will likely use. A student copier has also been furnished to reduce cost. All proceeds that ASA makes are returned to the students through a variety of activities, such as movie nights and cookouts, or by purchasing items aimed at making a student's life more comfortable, such as TVs or microwaves. The student association web page (http://asa.afit.edu) contains information on student events and a means to contact the current leadership with questions and/or ideas.

RESOURCES

5 ACADEMIC INFORMATION

Academic Policies

Academic Year

The academic year is divided into four 11-week quarters (fall, winter, spring, and summer), each of which includes a week for final exams. Full-time military students assigned to AFIT attend a 4-week technical review session ("short term") commencing in August, following student orientation.

Auditing

Students wishing to audit a course need only obtain permission from the instructor teaching that course and register according to prescribed procedures. Audited courses will not appear on official transcripts and will have no bearing on GPA.

Classification of Students

Full-time students must be fully enrolled in an approved curriculum each quarter they are in residence. Full-time enrollment normally amounts to 12-16 credit hours in a master's program and 9-12 credit hours in a doctoral program. Students may register for more than 16 credit hours if their cumulative GPA is 3.75 or higher and they receive permission from their academic advisor.

Part-time students are limited to courses totaling no more than eight quarter hours in a single quarter. Once admitted, part-time students are subject to the academic rules and regulations that apply to full-time students.

Course Offerings and Schedule

Projected course offerings for an academic year are typically published on the Graduate School's web site. Final schedules are available one quarter in advance of the quarter when the courses are actually taught. Students receive their individual course schedules during the sixth week of the quarter prior to the start of classes. The Institution reserves the right to cancel courses for administrative purposes.

Education Plans

The advisor and the student are responsible for developing, reviewing, and maintaining the student's specific plan of study, called an Education Plan. The Education Plan is developed within two weeks after matriculation. Both the student and the faculty advisor must review the Education Plan at least one quarter prior to the quarter in which courses are actually taught because it is used as the primary method for course registration.

Once the Education Plan is approved, it becomes the curriculum for that individual student, and deviations are permitted only if the student obtains formal approval for the change from the faculty advisor and the Department Head. All such changes are incorporated into the student's Education Plan and placed on file in the appropriate department.

Faculty Academic Advisor

Each student is assigned a faculty academic advisor who assists with academic planning and career development. While advisors are available for advice and consultation, students are responsible for understanding the Graduate School's academic policies and completing all graduation requirements.

Registration

Students must be admitted into the Graduate School of Engineering and Management in order to register and earn credit for coursework. The responsibility for being properly registered for courses rests with the student. Registration is required for each term for all students who enter coursework for credit. Registration instructions and guidelines can be obtained from the Registrar's Office, and the registration dates are published on the AFIT web site at http://rr.afit.edu. Registration is not permitted until tuition and fees are paid, where applicable.

Registration Changes

Students can make changes in their registration by submitting a Drop/Add form to the Registrar's Office. These forms are available in both the academic department and the Registrar's Office. Courses may be dropped without recording the course on the student's permanent academic record during the first two weeks of course subject to approval of the student's faculty advisor. Students should refer to the academic calendar for specific deadlines for dropping/adding courses. The most current calendar is posted by the Registrar's Office on their web site.

Students may withdraw from a course through the eighth week of the quarter. Any student who drops a course during the third week to the end of the fifth week will receive the grade of "W". Students dropping a course during week six through the end of the eighth week will receive a grade of "WF" or "WP". Normally, withdrawals are not permitted after the eighth week.

Repeated Courses

A student may not repeat a course or courses to improve a GPA where the original grade was a C or better.

Transfer of Credits

Students in master's degree programs may transfer up to 12 credit hours of graduate credit from other accredited institutions. The faculty advisor, the head of the appropriate department, and the Academic Standards Committee must approve transfer credits. Neither the grades nor the credit hours pertaining to the transferred courses will be used in grade point average calculations except to remedy academic deficiencies.

Grading

Grade Reports

Final grade reports follow the normal grading system. These reports are provided to each student.

Change of Address

Students who have a change in their permanent or local address while attending AFIT should report the change in writing to the Registrar. Billing address changes should be reported to the Bursar.

Grading System

Academic achievement is indicated by the following letter grades and points used in calculating the grade point averages:

Grade	Meaning	Grade Points
A	Excellent	4.0
A-		3.7
B+		3.3
B	Good	3.0
B-		2.7
C+		2.3
C	Fair	2.0
C-		1.7
D	Poor	1.0
F	Fail	0
IP	In Progress (MS)[1]	
P	Progress (PhD)[1]	
I	Incomplete[1, 2]	
W	Withdraw[1]	
WP	Withdrew Passing[1]	
WF	Withdrew Failing[1]	
NG	No Grade Submitted[3]	
S/U	Satisfactory/Unsatisfactory[1, 4]	
AU	Audit[1]	

[1] Does not count toward earned credit hours nor do they affect GPA. The grades "IP" and "P" are given for satisfactory progress in thesis and dissertation research courses.

[2] Automatically converted to F if the remaining course requirements are not resolved by week six of the next academic quarter. For research courses, the academic advisor, in coordination with the Dean, will determine the resolution deadline.

[3] Please see your instructor as soon as possible.

[4] Grades apply only to pass/fail courses.

Incompletes

Incomplete grades are given for failure to complete the required work on a course or thesis. A grade of "I" is subject to approval by the Dean. A student cannot graduate with a grade of "I." The student must resolve an incomplete given in a regular course by the sixth week of the following quarter. If the incomplete is not resolved, then grade will automatically revert to an "F." An "I" in an independent study course (thesis) must be replaced with a letter grade within a reasonable time period as agreed upon by the thesis advisor and the student.

Appeal of Grades

A student who feels that an assigned grade is other than the grade earned must first discuss the matter with the course instructor to determine if the discrepancy is caused by error or misunderstanding.

If the complaint is not satisfactorily answered by the instructor, and the student feels that an error has not been corrected or that the assigned grade was capriciously or unfairly determined, the student may appeal the decision to the head of the department in which the course is offered. After discussing the matter with the student, the head will consult with the course instructor and report a decision to the student. The final authority in the determination of the grade, however, rests with the course instructor.

Transcripts

Upon receipt of a written, signed request, the Registrar's Office will issue a transcript of work completed at the Institution, provided all obligations to the school have been met, including all financial accounts with AFIT where applicable. A transcript is official only when it bears the signature of the Registrar and the seal of the Institution. Transcripts mailed directly to the student will be stamped "Issued to Student" and normally are not accepted as *official* copies. Transcripts are free of charge. Allow five business days for verification and processing.

Transcripts, or copies of transcripts, from other colleges or institutions used for admissions will not be released by the Institution and must be obtained by the student from the institution holding the original record.

Confidentiality of Academic Records

The Family Education and Privacy Act of 1974, as amended is a federal law that grants to students the right to inspect, obtain copies, challenge, and to a degree control the release of information contained in his/her records. Guidelines and a full text of the law can be obtained from the Registrar's Office.

Academic Performance

Academic Integrity

Students are expected to adhere to the highest standards of academic integrity, in accordance with Air University Instruction 36-2309, *Academic Integrity.* Individuals who violate this instruction are subject to adverse administrative actions including enrollment termination. Military students may be discharged from the service or face disciplinary action including punishment under Articles of the Uniform Code of Military Justice or comparable discipline for non-military students.

Student Advising

The dean, faculty and staff are available for consultation with individual students as well as with sections of students. Each student has a faculty advisor, a professor appointed by the department head on the basis of familiarity with Institute programs, the students' programs, and the student's individual background.

Attendance Policy

Prompt and regular attendance is considered necessary for satisfactory work. Therefore, students are expected to attend classes, and absences should be explained to the instructor. The student should provide advance notice, if possible. This is especially important in the case of full-time officers assigned to AFIT, since they attend AFIT as an official duty assignment. Therefore, class attendance is absolutely mandatory unless the student is formally on leave or in another non-duty status.

A satisfactory explanation of absence may secure students from disciplinary action, but does not in any case relieve them from responsibility for the work during their absence. A student who misses an announced test, examination, or laboratory period in a regular course of study, and has the permission of the instructor, may be given the opportunity to make up the work at the instructor's convenience. The instructor determines in all instances the extent to which absences and tardiness affect each student's grade.

Students may be dropped at any time by a course instructor or the dean for non-attendance or tardiness with a grade of *W, WP,* or *WF*.

Academic Honors (Awards)

Several awards are presented to students by the various departments, professional associations, and the Institute. AFIT academic honors include the Commandant's Award, the Mervin E. Gross Award, and the designation of students as "distinguished graduates."

The Commandant's Award is presented to the student with the most outstanding thesis in the graduating class, which is selected from single entries from each department. The department nominees also receive the Dean's award to recognize the most exceptional thesis in each department.

The Mervin E. Gross Award is given to the graduating student who has demonstrated the most exceptional academic achievement and high qualities of character, initiative, and leadership while pursuing a master's degree in the Graduate School of Engineering and Management.

The Air Force Institute of Technology awards academic performance during graduation by designating certain students as "distinguished graduates." The number of distinguished graduates is limited to no more than 10% of the graduating class.

Academic Good Standing

To remain in good academic standing, all students must maintain a cumulative GPA of 3.0.

Probation and Dismissal

Failure to meet established minimum acceptable standards of academic or disciplinary performance could result in probation or dismissal. The academic advisor will counsel students failing to maintain the minimum GPA, and the advisor will develop a plan to help the student remedy the deficiency. At this point the student is considered on academic probation. A student on probation is considered in "good standing" for certification purposes and is eligible to register for courses. No entry is made on the student's permanent record. Failure to meet the minimum academic standard after the probationary period could result in the student meeting an academic review board.

The purpose of the academic review board is to recommend to the Dean whether the student should be eliminated from or be allowed to continue with his/her academic program. A faculty board should be convened for any student who receives a letter grade of "F" or "U" in any course, any student at the request of his faculty advisor, any student by his own request, any doctoral student at the request of the academic department, and any graduate student with a cumulative GPA less than 2.6 by the end of the second quarter, less than 2.7 by the end of the third quarter, less than 2.8 by the end of the fourth or subsequent quarters, and any graduate student with a cumulative or quarterly GPA less than 2.50.

Dismissal is a permanent and involuntary separation of the student from AFIT. The student is not eligible for readmission and is not in good standing in the Graduate School of Engineering and Management. "Academic dismissal" is permanently recorded on the student's permanent record.

6 GRADUATE DEGREE REQUIREMENTS

Master of Science Programs

All master's degree programs consist of five elements, all of which must total a minimum of 48 credit hours to earn the degree. These elements include:

1. Core courses that provide the breadth of content in a particular field, and they are identified by the department as those courses in which each student must demonstrate competence in order to meet the academic requirements of the particular field.
2. A specialization area* which provides in-depth knowledge in a chosen field.
3. Electives* that are used to round the student's experience or provide additional background material.
4. A mathematics requirement.
5. An independent research project, which carries a 12-credit-hour load.

* Students choose their electives and specialization courses based on their academic interest and the requirements of the Air Force for those military officers enrolled in AF sponsored programs.

Note: Military students who are assigned full-time to AFIT typically average 12 credit hours per quarter for the entirety of their program, resulting in substantially more than 48 quarter hours of study.

General Degree Requirements

The Master of Science and the Master of Science in Engineering degrees are awarded for the successful completion of a curriculum that has the approval of the faculty as meriting the award of that degree. To satisfy the specific requirements for the master's degree the student must:

1. Complete at least 48 quarter hours of required graduate courses and approved graduate electives.
2. Apply for candidacy at least one year prior to graduation. Candidacy is automatically granted for both Air Force students who are assigned to the Graduate School and students who are assigned to AFIT by other services and foreign countries. All other students are admitted into candidacy after petitioning the Dean through the department. Candidacy for these students requires the satisfactory completion of 12 quarter-hours of coursework with a minimum of a 3.0 grade-point average, and the student must file an Education Plan through a faculty advisor within the appropriate department.
3. Fulfill the appropriate residency requirement.
4. Complete an independent investigation of a problem approved by the major department, the results of which have been presented as a formal thesis. This thesis must be acceptable as partial fulfillment of the required quarter hours of credit. In certain programs, approved in advance by the Faculty Council, group design studies may replace the independent study.
5. Attain a grade point average of at least B (3.00) for all graded courses included in the student's approved program. Courses for which the student received the grade "D" or lower will not be accepted as a part of the 48 quarter hours required for the degree.

6. Complete all degree requirements within six calendar years after applying for admission as a candidate for the degree.
7. Be recommended for the degree by the Faculty Council of the Graduate School of Engineering and Management.

The degree title is either "Master of Science" or "Master of Science in (designated area) Engineering." Although the graduate programs for engineering students pursuing either degree are normally the same, the designated degree in engineering is awarded only to students whose total preparation, undergraduate and graduate, satisfy the appropriate accreditation criteria of the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

Academic Standards

The Graduate School expects its students to meet fully the rigorous demands of its programs. For many students, this means a weekly investment averaging at least three hours per quarter-hour of graduate registration.
Students are expected to maintain a 3.00 grade point average for all of their courses. In case of serious academic deficiencies, students must consult their faculty academic advisors regarding an appropriate study load to remedy their deficiencies.

Thesis Requirement

A student seeking a master's degree is required to pursue an independent study and submit a thesis in partial fulfillment of their degree requirements. The student is required to present the thesis at a formal defense to a faculty committee chaired by the research advisor. Upon successful completion of the defense, the student will submit a final document that contains a thesis approval page signed by the thesis examination committee. The administrative requirements for the thesis document are fully described in *Style Guide for AFIT Theses and Dissertations*.

Doctor of Philosophy Programs

Purpose

The AFIT doctoral program is based on the following statement by the Council of Graduate Schools in the United States (from The Doctor of Philosophy Degree: A Policy Statement, Oct 1977):

> The Doctor of Philosophy degree is awarded by universities in many parts of the world as the mark of highest achievement in preparation for active scholarship and research.
>
> The doctoral program is designed to prepare a student for a lifetime of intellectual inquiry that manifests itself in creative scholarship and research. The program emphasizes freedom of inquiry and expression and development of the student's capacity to make significant contributions to knowledge. An essential element is the development of the ability to understand and evaluate critically the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge. All of this is most effectively accomplished in close association with those experienced in research and teaching.

A central purpose of doctoral programs is the extension of knowledge, but this cannot be accomplished on all fronts simultaneously. Students must choose an area in which to specialize or a professor with whom to work. Individualized programs of study are then developed and committee members are selected cooperatively as course work is completed and research undertaken. When all courses have been taken, the research finished, the dissertation written, and all examinations passed, the student will have acquired the knowledge and skills expected of a scholar and will have extended knowledge in the field.

Details of requirements and policies are documented in AFIT instructions, Graduate School of Engineering and Management instructions, and Doctoral Council policy letters. These are available at AFIT.

General Degree Requirements

The Doctor of Philosophy is awarded for the successful completion of a curriculum that has the approval of the faculty as meriting the degree. The Ph.D. degree includes the following general requirements: (1) comple an approved program of study, (2) meet the residency requirement, (3) pass qualifying examinations, (4) be admitted into candidacy, (5) submit a dissertation, and (6) the successful defend the dissertation. These requirements, policies, and procedures that implement the program are discussed in the following sections.

Advising

Upon admission of each student into the program, a pro-tem faculty advisor is appointed by the Department Head to guide the student through the initial phases of the coursework, and suggest potential specialization areas. The pro-tem advisor is responsible for providing the student with advice on an appropriate plan of study and helping the student identify a research area and research advisor. A pro-tem advisor serves until the research advisor is selected and approved.

Upon selecting a field of specialization (research area), the student chooses a regularly appointed faculty member in that area to act as his/her research advisor and research committee chairperson. In many cases, the pro-tem advisor becomes the research advisor. The research adviser supervises the specialty examination and advises the student throughout the remainder of the program concerning the prospectus, the research project, writing of the dissertation, and any other matters pertaining to the program. The research adviser also chairs the research committee, which shall consist of no fewer than three faculty members, representing at least two academic departments from within the Graduate School of Engineering and Management. The department head of the admitting department must approve changes in the composition of the research committee.

Course Requirements

The student must complete at least 48 quarter hours of course work of which at least 24 quarter hours must be successfully completed in the major area and at least 12 quarter hours must be successfully completed in the minor area. The remaining hours are used to satisfy a mathematics requirement and other electives. The minimum 24 hours of major area courses may consist of courses from more than one department as long as these courses form an integrated program designed to make the student an expert in the chosen area of research. The minor is intended to be a broadening graduate sequence. The minor courses may be in the same department as the major, but normally they will represent a different subject matter from the major. The minor may include first year graduate courses, but if undergraduate prerequisites are necessary they will be in addition to the 12 hours required. The individual departments approve the specific courses that will constitute the major and minor areas of study.

The residency requirement is met when the student completes three quarters of full-time study in residence during any contiguous four-quarter period. The student must also attain an average grade of at least B (3.00) for all courses attempted after admission to the program. For the Ph.D.

program, qualifying examinations and the dissertation are paramount, and course requirements are identified to facilitate the student's education towards the qualifying examination.

Waivers may be granted to the 48 quarter hour requirement. Such a waiver would require documentation that the student has previously successfully completed courses normally included in the AFIT Ph.D. program of his or her chosen discipline, and that the program constitutes a well-integrated specialty, minor, and/or mathematics sequence. No more than 12 credit hours may be waived under this provision.

Academic Load

Full-time students are expected to carry a full academic load of 12 credit hours per quarter. Except in unusual circumstances, no student should carry more than 12 credit hours per quarter. The head of the admitting department may grant an exception to this guideline. This 12 credit hour limitation is based upon the following items:

1. The Ph.D. courses are of such advanced nature that a student needs time to understand and assimilate the material contained therein.
2. The limitation allows time to interact with other Ph.D. students and with the faculty.
3. It allows time to explore areas that may intrigue him or her in the pursuit of the course work.

Generally, a full-time Ph.D. student will complete complete course requirements during the first four or five quarters. During the succeeding quarters, the student's full load involves completing the examination requirements and working on his or her dissertation research.

Standards of Work

Each student is expected to perform at a high academic level and maintain a grade point average of at least B (3.00) on the course work. In addition, he/she must pass the examinations and be admitted to candidacy on a timely basis. Any course grade less than B constitutes a deficiency. Failure of the specialty exam or the minor exam constitutes a deficiency. An academic board is usually convened if a student has two deficiencies. The board reviews the situation and may dictate corrective action or may take action to remove the student from the program.

Qualifying Examinations

The two PhD qualifying examinations are the "specialty exam" and the "minor exam." The latter may be waived on the basis of strong performance in the courses.

A written and oral examination in the specialty area is required for each Ph.D. student. The oral part may be included in the Prospectus Examination or it may be part of the specialty examination or both. The specialty examination has two objectives: to measure the student's mastery of the specialty area and to measure his or her readiness to define a dissertation research area.

Prospectus Examination

The Research Committee will examine the student on the prospectus that the student has submitted. Normally this examination will be an oral examination conducted after the committee has had an opportunity to study the prospectus. The prospectus examination will be graded as "pass" or as "not yet ready." Therefore, it can be viewed as an ongoing process, in which the "defense" can be adjourned and reconvened (as necessary) until the committee accepts the prospectus.

Admission To Candidacy

The graduate student does not formally become a candidate for the Ph.D. degree until the application for candidacy is approved. Admission to candidacy requires the approval of the student's supervisory committee, the Department Head, and the Dean of the Graduate School. The approval is based upon (1) passing the qualifying examinations, (2) an academic record of the student that meets the program and grade point average requirements, and (3) approval of the student's prospectus for the dissertation project. The formal application for candidacy should be submitted as soon as these requirements are met and at least one year prior to receipt of the degree.

Dissertation Requirement

The most clearly distinguishing characteristic of a program leading to the Ph.D. degree is the requirement that the candidate write a dissertation embodying the results of a significant and original investigation. The dissertation must make a real contribution to the engineering or applied science discipline chosen by the student, and it is expected to be a mature and competent piece of writing. With the exception of such progress reports as may be required by the sponsoring agency, no publication of the results of dissertation research will be made prior to acceptance of the dissertation without the approval of the student's Research Committee. While research in a classified area is acceptable, the dissertation document must be unclassified, stand alone, and be available for unlimited distribution. Details regarding administrative requirements and style suggestions are provided by the *Style Guide for AFIT Theses and Dissertations*.

Defense of the Dissertation

The oral defense of the dissertation constitutes the final examination of the student's work. This examination must enable the research committee, augmented by the Dean's representative, to satisfy itself that the dissertation is an original piece of work that has been carried out in keeping with the highest standards of investigation and reporting, and that it makes a contribution to knowledge that is of value to the engineering profession or scientific community. The written dissertation and the results of this defense will be judged satisfactory if they have the approval of a three-fourths majority (including the Advisor) of the evaluation committee. The committee may approve the defense subject to still further revisions in the written dissertation. This has been the rule rather than the exception. Therefore, the candidate should retain all materials, files, etc. that would be needed to make those revisions until the Dean has approved the dissertation and all necessary copies have been produced and accepted.

Time Limitation

All requirements for the Ph.D. degree must be satisfied not later than eight years from the beginning of the first course in the approved program and not later than four years from admission to candidacy. The time limit may be waived by the faculty council when appropriate, such as when the research has been vigorously pursued but is delayed by circumstances beyond the control of the student.

7 GRADUATE PROGRAMS

Department of Aeronautics and Astronautics

Department of Aeronautics and Astronautics
AFIT/ENY
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Department Head: Professor Bradley S. Liebst

Introduction

The Department of Aeronautics and Astronautics provides educational expertise at the graduate level in Aeronautical Engineering (GAE), Astronautical Engineering (GA), Materials Science (GMS), Systems Engineering GSE), Space Operations (GSO), Mechanical Engineering, and Engineering Mechanics. The major departmental effort is devoted to teaching and research in support of programs leading to the Master's degree in the first five of these program areas and Doctoral studies in any area of departmental activity.

Faculty

Professors

Robert A. Calico
(structural dynamics)

Milton E. Franke
(aerodynamics, propulsion, and weapons)

Bradley S. Liebst
(dynamics and control)

Shankar Mall
(AFRL Professor — materials)

Anthony N. Palazotto
(structural mechanics)

William Wiesel
(astrodynamics)

Associate Professors

Robert A. Canfield (aeroelasticity and structural design)

Wayne F. Hallgren
(aerodynamics and aircraft performance)

Paul I. King
(propulsion and aerodynamics)

Curtis H. Spenny
(systems engineering)

Assistant Professors

Gregory S. Agnes
(structural vibrations)

Jeffrey P. Bons
(experimental aerodynamics)

Montgomery C. Hughson
(computational fluid dynamics)

David R. Jacques (dynamics and control)

E. Price Smith
(system engineering)

Steven G. Tragesser
(astrodynamics)

Emeritus Faculty

William Elrod
(propulsion)

Peter Torvik
(dynamics)

Programs of Study

Aeronautical Engineering (GAE)

This master's degree program provides the student with a broad background in aeronautical engineering and in-depth specialization in one or more of the areas of aerodynamics, propulsion, structures, and flight mechanics. The program leads to the degree of Master of Science in Aeronautical Engineering (ABET-accredited) or Master of Science. The students should possess an ABET-accredited baccalaureate degree in aeronautical, aerospace, or mechanical engineering, or engineering mechanics.

Each student who graduates with a Master of Science degree in Aeronautical Engineering must have a foundation in the theoretical and applied aspects of the fundamental areas of aeronautical engineering. All students must take at least one course in graduate aerodynamics and flight mechanics, which defines the basic core requirement. The department also offers core electives for those students who seek an ABET-accredited degree and are deficient in the prerequisites for this degree.

Several specialty areas are offered to provide the student with the opportunity to concentrate in a particular area of study. The specialty areas include:

a. Fluid mechanics and aerodynamics with an emphasis in aerodynamics, hypersonic aerodynamics, heat transfer, computational fluid dynamics, and propulsion;
b. Solid mechanics, which offers the student specialized study in structural materials and analysis, vibration damping and control, and aeroelasticity; and
c. Flight mechanics and systems, which provide opportunities to study aircraft stability and control, control and optimization theory, air weapons, reliability, aerospace robotics, and systems analysis and design.

Students with a mechanical engineering background complete the core requirements for the aerospace engineering program. They subsequently specialize in those courses that strongly emphasize the mechanical sciences, such as structural materials, structural analysis, structural dynamics, robotics, heat transfer, airbreathing propulsion, and rocket propulsion.

Joint AFIT/Air Force Test Pilot School Program: An option in flight test engineering, open only to a limited number of Air Force officers, is conducted through a cooperative arrangement with the USAF Test Pilot School (TPS) at Edwards AFB CA. Students are chosen for this option from those selected for TPS who are academically eligible volunteers for a resident graduate program in Aeronautical Engineering. A curriculum emphasizing flight mechanics is completed in AFIT residence and is followed by completion of the 12-month TPS course. The thesis, emphasizing flight test engineering, is jointly sponsored by AFIT and the TPS and is begun in residence at AFIT and completed at the TPS. The AFIT degree is awarded upon satisfactory completion of the thesis and the TPS phase. Graduates will be assigned directly to flight test positions.

Astronautical Engineering (GA)

This master's degree program provides the student with a broad education in the scientific and engineering disciplines associated with astronautical engineering. The curriculum provides the necessary preparation for the student to make direct contributions as an engineer in the astronautical engineering field and prepares him or her to evaluate, monitor and administer astronautical research and development projects. Students entering the Astronautical Engineering program should have an ABET-accredited baccalaureate degree in an appropriate area, e.g., astronautical engineering, aeronautical engineering, aerospace engineering, mechanical engineering, electrical engineering, or engineering mechanics.

Any two graduate-level astronautics courses fulfill the core requirements for the degree. For those students who are deficient in the requirements for an ABET-accredited degree, or lack the necessary undergraduate preparation, the department offers several electives to remedy the deficiency.

The specialty areas provide concentrations in guidance and control, propulsion, instrumentation, and structures. A special program in space facilities is offered for officers in the Civil Engineering career field to prepare them for roles in the development and operation of launch facilities and large permanent space facilities. The courses are chosen to develop an in-depth knowledge of a specific area directly related to the operation of a large permanent space facility.

Aerospace and Information Operations (GAI)

This master's degree program prepares the student for management and analysis roles in planning, executing, and evaluating space operations, particularly as they relate to the flow of information. The program is highly interdisciplinary in nature; all students study subjects in areas of space sciences, operational sciences, space engineering, and systems engineering. In addition to this broad background, students learn about vulnerabilities and opportunities for exploitation of information infrastructures. The program also studies how the flow of information affects the battlefield environment. The Aerospace and Information Operations graduate is prepared to apply a variety of analysis techniques toward accomplishment of the full spectrum of military space missions and information operations.

The GAI program attracts students without formal engineering backgrounds. Therefore, the minimum entrance requirements for this program (in addition to AFIT's requirements) include calculus-based general physics or equivalent engineering courses (two semesters or three quarters) that must include mechanics (statics and dynamics), electromagnetic theory, and electronics; a minimum of 8 semester hours or 12 quarter hours of differential and integral calculus; one course in differential equations; and one course in computer programming or equivalent experience.

The core requirements for the program include courses in space dynamics (MECH 532), sensor systems (PHYS 521), space environment (PHYS 519), telecommunications (EENG 571), and spacecraft systems design (SENG 631). The information operations sequence consists of courses in information warfare (CSCE 525), simulation (OPER 561), and information operations (OPER 676). Full-time quota students take an additional elective sequence to achieve a deeper understanding of a space or information related area.

Materials Science (GMS)

This master's degree program is designed to provide a student who has a background in engineering or physical science with the knowledge of materials science and engineering necessary for work in the fields of structural and non-structural materials for aerospace systems. Emphasis is placed on the application of fundamental knowledge to the design, development, test, and evaluation of materials for Air Force systems. The program is under the joint supervision of the Department of Aeronautics and Astronautics and the Department of Engineering Physics and is carried out in cooperation with the Materials and Manufacturing Directorate of the Air Force Research Laboratory. In general, students entering this program should have an undergraduate major in aeronautical engineering, mechanical engineering, materials science and engineering, electrical engineering, applied physics, or physical chemistry. It is desirable for entering students to have taken undergraduate courses in an introduction to materials science, physical chemistry, differential equations, and strength of materials.

The program provides the student with a strong background in thermodynamics and kinetics of materials, mechanical, electronic and optical properties of materials, material characterization, material selection and processing, and mathematics. Therefore, the core courses for this program include MATL 545 (Mechanical Properties of Materials), MATL 525 (Thermodynamics and Kinetics of Materials), MATL 560 (Electronic, Magnetic, and Optical Materials), MATL 680 (Materials Characterization), and MATL 685 (Materials Selection and Processing).

Each student is also required to undertake an in-depth study and research either in structural materials (metallic, composite, polymer, ceramics, etc.) or non-structural materials (electronics, optical, magnetic, dielectric, coating, etc.). The student may select specialization courses offered by either the Department of Aeronautics and Astronautics or by the Department of Engineering Physics. Typical specialty areas include behavior of structural materials; electronic and optical materials; computational materials; chemistry of materials; and polymer-based materials.

The independent research portion of this program may be conducted under the direction of either the Department of Aeronautics and Astronautics or the Department of Engineering Physics and can be performed either at AFIT or at a directorate of the Air Force Research Laboratory. Flexibility in the program is maintained in order to take full advantage of the varied backgrounds and abilities of individual students.

Space Operations (GSO)

This master's degree program prepares the student for management and analysis roles in planning, executing, and evaluating space operations. The program provides education in different scientific and engineering areas concerning space operations, and on quantitative and qualitative approaches to the planning and execution of space missions. The program is highly interdisciplinary in nature; all students study subjects in areas of space sciences, operational sciences, space engineering, and systems engineering. The Space Operations graduate is prepared to apply a variety of analysis techniques toward accomplishment of the full spectrum of military space missions. The minimum entrance requirements for this program are identical to the Graduate Aerospace and Information Operations (GAI) program.

The core requirements for the program includes courses in space dynamics (MECH 532), sensor systems (PHYS 521), space environment (PHYS 519), telecommunications (EENG 571), operations research (OPER 501 or OPER 510 or OPER 543), information warfare (CSCE 525), and spacecraft systems design (SENG 631). Full-time quota students take an additional elective sequence to achieve a deeper understanding of a space-related area.

Systems Engineering (GSE)

Systems engineering is the application of scientific and engineering knowledge to the analysis and design of complex systems and their associated components, a system being a collection of objects that operate together to perform some function. The goal of the systems engineer is to understand the entire system, its internal structure, and its interactions with its environment. This understanding forms the basis for both analysis and synthesis of systems.

Typically, the systems engineer is required to develop system objectives and means of measuring satisfaction of those objectives, create feasible alternatives, and apply rational decision-making procedures to select the best solution. In addition, the large-scale problems involved generally require team efforts for solution. Systems engineers must be able to understand and integrate contributions from other specialists, as well as make their own contributions. Thus, the systems engineer must be a generalist, with a broad interdisciplinary background, but with depth of knowledge in a particular specialty. The Systems Engineering curriculum at AFIT is structured to develop such a person. The student can enter this program with an ABET-accredited baccalaureate degree in any engineering discipline.

The systems engineering core courses comprise systems engineering (SENG 520), linear systems (SENG 525), deterministic operations research (OPER 510), and engineering economics (ENVR 580).

In addition to the core, each student takes a specialty sequence in an engineering discipline. This is an elected group of courses which form a coherent unit and contain sufficient engineering content to qualify the student for the ABET degree. The courses may be chosen from any of the various engineering areas such as aerodynamics, structures, propulsion, digital control, communication systems, flight vehicle mechanics, or software engineering, which are offered by the Departments of Aeronautics and Astronautics, Electrical and Computer Engineering, Engineering Physics, and Systems and Engineering Management. It is recommended that the specialty area be chosen to provide a continuation of the student's undergraduate major.

The group design project provides an opportunity to apply the tools and techniques developed in the program to a real design problem. The class is divided into design teams (typically five to eight students per team), each of which works on a topic of current interest to the Air Force or DoD. The resulting research reports are accepted in lieu of individual theses. Some topics have included: design of an active anti-missile defense system for the C/KC-135 aircraft, assessment of environmental risk and remediation options for depleted uranium contamination, optimized design of a two-stage intercontinental ballistic missile, and design of a combined satellite attitude control and energy storage system using flywheels. Design studies such as these allow the students to apply the principles taught in the program to a realistic problem while still in an academic environment. This design experience is outstanding preparation for the practicing systems engineer.

Doctor of Philosophy (Ph.D.) Program

The Department of Aeronautics and Astronautics offers studies leading toward the Ph.D. degree in Aeronautical Engineering, Astronautical Engineering, or Materials Science. In the case of the Aeronautical and Astronautical Engineering programs, students will concentrate in one of the three major disciplinary divisions of the Department of Aeronautics and Astronautics: (1) Fluid Mechanics, (2) Solid Mechanics, or (3) Dynamics, Systems, and Control. A doctoral specialty may be pursued in any of the areas of concentration within the department. Specialty coursework generally consists of one or more graduate sequences, augmented by the more advanced courses that are offered for doctoral students. Students interested in a doctoral program should discuss those interests with a member of the department who is actively engaged in research in an area of interest to the student.

Facilities

The research laboratories of the Department of Aeronautics and Astronautics are equipped for the study of fluid mechanics, solid mechanics, and system dynamics and control. Laboratory facilities specifically support lecture courses, laboratory courses, faculty research, and student thesis research at Master's, Ph.D., and post-doctoral levels.

The laboratory facilities are comprised of general instrumentation and equipment, which are shared by a variety of facilities. These research facilities are dedicated to specific research topics and have unique equipment and instrumentation requirements. The facilities are housed in three different buildings. Buildings 640 and 644 have 17,260 square feet of general laboratory facilities and Building 19 has 15,000 square feet of floor space dedicated to housing a five-foot wind tunnel, high-pressure shock tube facility, nine-inch low velocity wind tunnel, and turbine cascade facility.

Support instrumentation and sensors include: digital data acquisition systems, Schlieren, Moiré, shadowgraph, high-speed video recording equipment, one and three component laser velocimeter, hot wire anemometers with linearizers and signal conditioners, optical equipment, modal analyzers, frequency spectrum analyzers, multi-port pressure measuring systems, material test and characterizations facility, material preparation facility, and a full range of transducers (temperature, force, pressure, acceleration, displacement).

Research

The Department of Aeronautics and Astronautics has three major areas of expertise: (1) Fluid Mechanics and Energy Transmission, (2) Solid Mechanics and Structures, and (3) Dynamics, Systems, and Controls. Each of these areas provides ample research opportunities for the student:

(1) The Fluid Mechanics and Energy Transmission area encompasses research in aerodynamics, (compressible, incompressible, viscous and computational), propulsion (air-breathing, rocket, and non-chemical), and heat transfer (convection, conduction, and radiation). Computational fluid dynamics research includes hypersonic flow field simulations for applications such as the high-speed test track facility at Holloman AFB. Experimental wind tunnel researchers seek to control unsteady boundary layer flow separation in turbomachinery using microelectromechanical (MEMS)-based passive and active devices. Ongoing propulsion research is examining the unsteady aerodynamics in internal combustive flow with the goal of eliminating high cycle fatigue in jet turbine engines.

(2) The Solid Mechanics and Structures area encompasses research topics such as applied mechanics (elasticity, plasticity, and continuum mechanics), structures (stability, shells, finite element methods, and design optimization), structural dynamics (mechanical vibrations, wave propagation, and aeroelasticity), and structural materials (fracture mechanics, composite materials, and fatigue). Structural dynamics researchers focus on detecting damage in flexible space structures using modal analysis and finite element updating schemes. Experimental vibration researchers fabricate and test novel concepts for space optics, adaptive structures, and inflatable membrane structures for space antennas. Aeroelastic research is being conducted to better understand the limit cycle oscillation observed on fighter aircraft with certain store configurations. Experimental material characterization and nonlinear finite element plate and shell analysis is being applied to failure prediction of composite materials.

(3) The Dynamics, Systems, and Controls area includes research activities in aircraft flight mechanics (performance, stability, and control), astrodynamics (orbital mechanics and optimal trajectories) spacecraft attitude dynamics, systems (design and modeling of large-scale systems, and weapons analysis), and robotics (manipulators, remote systems, and man-in-the-loop control). Dynamics and Controls researchers are leading the way in understanding cooperative behavior and control of autonomous air vehicles such as smart munitions and uninhabited combat air vehicles (UCAVs). As-

trodynamics researchers are investigating formation flying with tethered satellites. Another research area in astrodynamics is mission planning for the space maneuver vehicle (SMV). Recent Systems Engineering projects include design of an unmanned aerial vehicle (UAV), investigation of the fidelity necessary for centrifuge-based dynamic flight simulation, and study of closely supervised reactive control for applications such as UAV and SMV.

Course Offerings

AERONAUTICS AND ASTRONAUTICS

AERO 517 – FLUID MEASUREMENTS LAB: An introduction to instrumentation and procedures used in the calibration of measurement systems and measurement of the static and dynamic response of fluid and thermal systems. Instrumentation includes oscilloscopes, anemometers (laser and hot-film/wire), pressure transducers, heat and temperature sensors, schlieren flow visualization, and other measurement systems at the discretion of the instructor. Prerequisites: SENG 516. 4 credit hours

AERO 520 – VISCOUS FLOW THEORY: Derivation of the Navier-Stokes equations. Exact solutions of the N-S equations, similarity variables. Boundary layer equation, Falkner-Skan solutions, momentum-integral methods. Factors affecting transition; turbulent boundary layers. Prerequisites: AERO 535 or equivalent. Fall Quarter 4 credit hours

AERO 535 – LOW SPEED AERODYNAMICS: Basic principles and analytical methods of the theory of motion of an inviscid incompressible fluid and flows associated with the motion of aerodynamic bodies. Prerequisites: Undergraduate Fluid Mechanics. Fall Quarter 3 credit hours

AERO 536 – HIGH SPEED AERODYNAMICS: Theory of compressible aerodynamics including classical gas dynamics, wave motion, normal and oblique shocks, Prandtl-Meyer expansions, linear airfoil theory, similarity rules and method of characteristics. Prerequisites*:* AERO 535. Winter Quarter 4 credit hours

AERO 542 – COMPUTATIONAL MODELING FOR AERODYNAMICS: An introduction to a variety of commercial and government software packages for the computer-aided analysis of aerodynamic flows. Topics will include grid-generation (e.g., with GRIDGEN), viscous flow computation (e.g., with ARC3D), and post-processing of computed data (e.g., with FAST). Emphasis will be given to a "hands-on" use of software for the analysis of practical applications in a laboratory environment. Prerequisites: Basic understanding of UNIX. Fall Quarter 2 credit hours

AERO 612 – PERTURBATION METHODS IN AIRCRAFT AERODYNAMICS: Description and application of perturbation methods to a variety of problems in aircraft aerodynamics. Analysis of regular and singular perturbation problems. Applications include boundary-layer theory, thin-airfoil theory (subsonic and supersonic), transonic small-disturbance theory, and hypersonic small-disturbance theory. Prerequisites: AERO 535 and AERO 536. 4 credit hours

AERO 622 – INTRODUCTORY HYPERSONICS: Characteristics of hypersonic flow and assumptions underlying inviscid hypersonic flow theories. Similarity, small disturbance and surface inclination methods are covered. The equivalence principle, blast wave methods, low density aerodynamics, high temperature aerodynamics and reentry trajectories are also discussed. Prerequisites: AERO 536. Fall Quarter 4 credit hours

AERO 623 – TRANSONIC FLOW THEORY: Classical methods and more recent procedures for solving transonic flow problems are examined. Inviscid transonic flow equations are derived and special characteristics of these equations, transonic similarity rules, peaky airfoils, and more recent numerical procedures plus boundary conditions, are discussed. Prerequisites: AERO 636. 4 credit hours

AERO 624 – ADVANCED HYPERSONICS: Concentrates on the fundamental aspects of viscous hypersonic flow, boundary layer results and aerodynamic heating relations. Topics include hypersonic boundary layer equations, hypersonic viscous interactions, transition, and high-temperature effects such as chemically reacting viscous flow. Also included will be an introduction to computational techniques relating to hypersonic flow problems. Prerequisites: AERO 520, AERO 622 and AERO 751. 4 credit hours

AERO 627 – TURBULENCE: Order of magnitude estimates for diffusivity, dissipation, and velocity and fundamental length scales in turbulence. Reynolds time averaging and mass averaging of the Navier-Stokes equations, the closure problem, and turbulent energy and vorticity balances. Boundary-free shear flows and wall-bounded shear flows for internal and external flows. Turbulence modeling, Statistical description of turbulence, Orr-Sommerfield analysis and the transition problem. Prerequisites*:* AERO 520. Spring Quarter
4 credit hours

AERO 636 – AERODYNAMICS OF WINGS AND BODIES: Mathematical modeling of lifting-surfaces and slender bodies for subsonic and supersonic flows. Application of perturbation methods to flowfield analysis, similarity rules (subsonic, supersonic and transonic), drag and lift calculations, and topics in unsteady aerodynamics. Prerequisites: AERO 536 and AERO 612.
4 credit hours

AERO 698 – GRADUATE SEMINAR IN AERONAUTICS AND ASTRONAUTICS: Current problems and solutions in the design of Air Force aeronautical and astronautical systems are presented by representatives of USAF agencies and the aerospace industry. Prerequisites: None. 0 credit hours

AERO 725 – HIGH LIFT AERODYNAMICS: Review of theoretical and applied aerodynamics. Second order theory of wings, deflection of the vortex sheet, slender wings of low aspect ratio, aerodynamics of propellers and rotors, unpowered flaps, jet flaps, ducted fans, boundary layer control, circulation control, and thrust augmenting devices. Prerequisites: AERO 535. 4 credit hours

AERO 729 – PHYSICAL GAS DYNAMICS: Kinetic theory and microscopic collisional concepts, chemical thermodynamics and the law of mass action. Internal structure and quantum energy states, general statistical mechanics applied to monatomic and diatomic gases, chemically reacting mixtures, dissociating gases, and ionized gases. High temperature properties of equilibrium air, application to shock waves, nozzle and Prandtl-Meyer flows. Prerequisites: Permission of Instructor.
4 credit hours

AERO 736 – AERODYNAMIC PANELING METHODS: An introduction to aerodynamic paneling methods. Source, vortex, and doublet singularity panels are developed. Boundary conditions are formulated to obtain linear algebraic equations for singularity strengths. Aerodynamic forces and moment equations are developed. Prerequisites: AERO 636. 4 credit hours

AERO 751 – FINITE-DIFFERENCE METHODS FOR FLUID MECHANICS: Finite-difference representation of partial differential equations (PDEs). Transformation of PDEs. Stability and consistency analysis for finite-difference procedures. Explicit and implicit formulations. Applications of finite-difference methods to selected model equations in fluid mechanics and heat transfer. Numerical methods for inviscid flow equations. Grid generation. Prerequisites: Permission of Instructor. Winter Quarter 4 credit hours

AERO 752 – COMPUTATIONAL AERODYNAMICS: Explicit and implicit algorithms for the solution of the incompressible Navier- Stokes equations and the compressible Euler equations. Analysis of schemes, including consistency, convergence, and accuracy. Prerequisites: AERO 751, AERO 520 or equivalent, and AERO 536 or equivalent. Spring Quarter 4 credit hours

AERO 753 – ADVANCED COMPUTATIONAL AERODYNAMICS: Analysis of implicit, finite-difference algorithms for compressible, viscous flows in two and three dimensions. Coordinate transformations, flux-vector splitting, numerical dissipation. Algorithm applied to problems of current interest. Analysis of modern shock-capturing methods, including Total-Variation-Diminishing schemes. Prerequisites: AERO 752. Summer Quarter 4 credit hours

AERO 799 – INDEPENDENT STUDY: Thesis research. Prerequisites: None. 1-12 credit hours

AERO 999 – DISSERTATION RESEARCH: Prerequisites: Approval of Research Advisor. 1-12 credit hours

MATERIALS SCIENCE

MATL 498 – MATERIALS SELECTION SEMINAR: Definition of material properties as they relate to load bearing structural materials. General discussion of constitutive equations and how material properties are necessary both for stress strain relationships and for limit load analyses. Presentations on the material characteristics, strengths, weaknesses, applications, problems, and current research objectives for airframe metals, high temperature metals, organic composites, metal matrix composite, carbon-carbon, viscoelastic materials, etc. Prerequisites: Strength of Materials Course. Fall Quarter 1 credit hour

MATL 525 – THERMODYNAMICS AND KINETICS OF MATERIALS: Applications of thermodynamics and kinetics relevant to materials science and engineering are presented. Concepts treated include free energy of phases, phase diagrams, metastability, and applications to problems in solids and thin films. Thermodynamis is applied to pure materials, solid solutions, phase equilibria, interfaces and defects. Kinetics topics include diffusion in solids, nucleation kinetics, composition-invariant solid/solid interface migration, and kinetics of surface deposition. Prerequisites: Undergraduate Materials Science Course Fall Quarter. 4 credit hours

MATL 545 – MECHANICAL PROPERTIES OF MATERIALS: Course is designed to provide a background for the understanding of the mechanical behavior of metals, ceramics, polymers, and composites in aerospace applications. Topics include behavior of materials under simple and combined stress systems, elastic and plastic behavior, strengthening mechanics, fatigue, creep, residual stress, fracture, and mechanical testing. Prerequisites: Undergraduate Materials Science Course. Summer Quarter 4 credit hours

MATL 560 – ELECTRONIC, MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS: Introduction to the theory and engineering applications of electronic, magnetic, and optical materials. Atomic bonding, crystal structure, crystal defects, lattice vibrations, band theory, metals, dielectrics, semiconductors, magnetic materials, ferroelectrics and superconductors are covered. Use of these materials in solid state devices, hard and soft magnets, superconductors, and optical devices are treated. Prerequisites: Undergraduate Materials Science Course. Fall Quarter. 4 credit hours

MATL 598 – MATERIALS AND PROCESSES SEMINAR: Current technologies, applications, and research issues in materials and processes are presented by experts from the Air Force, industries and other universities. Prerequisites: None. 1 credit hour

MATL 620 – CHEMISTRY OF MATERIALS: A study of the electrochemistry, inorganic chemistry, organic chemistry, polymer chemistry and solid-state chemistry relevant to synthesis processing of materials. Computational methods of predicting and correlating materials structure with properties or alternative materials will be introduced. This course introduces the student to chemistry of materials and chemical processes which use or produce significant quantities of toxic chemicals. Emphasis will be placed on chemistry of materials and processes important in current and future aerospace manufacture and maintenance. This course provides background for understanding pollution prevention. Prerequisite: CHEM 590. Winter Quarter 4 credit hours

MATL 662 – ELECTRONIC PROPERTIES OF MOLECULES AND SOLIDS: This course is an introduction to the electronic behavior of molecules and solid state materials with an emphasis on the symmetrization postulate, tight binding methods, band theory, Hartree Fock - self consistent field methods, configuration interaction methods, and density functional theory. Prerequisites: MATL 620, PHYS 655. 4 credit hours

MATL 672 – OPTICAL PROPERTIES OF MATERIALS: Study of the various optical phenomena in materials; topics will be selected from absorption, reflection and emission processes, luminescence, dispersion theory, optical materials, polymers, wave propagation in anisotropic media, and nonlinear properties of materials. Applications will be made to the material requirements of optical devices such as lasers, detectors, etc. Prerequisites: PHYS 670. Summer Quarter 4 credit hours

MATL 680 – MATERIALS CHARACTERIZATION: The objective of this course is to provide an integrated view of characterization as a process requiring application of many methods to extract information about a material. Two classes of methods are considered, those using particles and those using waves. Particles are grouped into photons (visible, infrared, ultraviolet, x-ray), electrons, and atoms/ions/neutrons. Frequency ranges of waves include acoustic and microwave. The challenge in characterization is to understand the probe-

material-sensor interactions, because these are drivers to characterizing the material. Only a few specific methods are covered as representatives of the several hundred methods now used. Prerequisites: Undergraduate Materials Science Course. Winter Quarter
4 credit hours

MATL 685 – MATERIALS SELECTION AND PROCESSING: An introduction to methods for logical choice of materials processes for applications with emphasis on aerospace requirements. Includes methods for assessment of risk and cost with respect to requirements. Prerequisites: Undergraduate Materials Science Course. Winter Quarter
4 credit hours

MATL 799 – INDEPENDENT STUDY: Thesis research. Prerequisites: None.
1-12 credit hours

MECHANICAL ENGINEERING

MECH 444 – ANALYSIS OF STRUCTURAL ELEMENTS: Definitions of stress, strain, compatibility, equilibrium and boundary conditions for two-dimensional elastic problems. Analysis of tension members, beams, torsion members and an introduction to energy methods; dummy load method. Prerequisites: Undergraduate Strength of Materials. 3 credit hours

MECH 500 – FUNDAMENTALS OF SOLID MECHANICS: Analysis of deformation, strain and stress continuum. Introduction to elasticity, including definitions of stress, strain, compatibility, equilibrium, generalized Hooke's Law, and boundary conditions. The Principle of Minimum Potential Energy is applied to beams in tension, torsion, shear, and bending. Torsion bars with non-circular cross-sections are analyzed by applying St. Venant's Semi-Inverse Principle. Prerequisites*:* Undergraduate Strength of Materials. Fall Quarter
4 credit hours

MECH 515 – THEORY OF VIBRATIONS: Free and forced vibrations of damped and undamped systems with a finite number of degrees of freedom. Characteristic frequencies and mode shapes. Generalized coordinates and normal modes. Free and forced vibrations of simple continuous systems: transverse oscillations of strings, longitudinal and torsional oscillations of rods. Prerequisites: MECH 423. Winter Quarter 4 credit hours

MECH 516 – EXPERIMENTAL MECHANICS II: An introduction to instrumentation and procedures used in the measurement of the dynamic response of structures. Instrumentation includes oscilloscopes, oscillographs, accelerometers, vibration exciters, and impedance heads. Measurements are made of structural damping, stiffness and resonances. Modal analysis techniques are demonstrated. Prerequisites: None. Corequisite*:* MECH 515).
1 credit hour

MECH 517 – VIBRATIONS MEASUREMENTS LAB: An introduction to instrumentation and procedures used in the measurement of the dynamic response of structures. Instrumentation includes oscilloscopes, oscillographs, accelerometers, vibration exciters, impedance heads, laser holography, and modal analyzers. Measurements are made of structural damping, stiffness, resonances, and displacements. Prerequisites: SENG 516. 2 credit hours

MECH 518 – DYNAMICS OF SPACE STRUCTURES: A survey course in structural dynamics providing the necessary background to make preliminary analyses of the ability of a satellite component to survive the launch environment and deployment and to model the space structure for purposes of control system design. Topics covered include load assessment, random vibrations, normal mode analysis, truss analysis, structural modeling, finite element analysis, controls, and deformation sensing. Prerequisites: MECH 444 or MECH 500. 4 credit hours

MECH 521 – Intermediate Dynamics: Three-dimensional kinematics using generalized vector notation, rotating and translating coordinate frames, particle and rigid body dynamics, equations of motion via direct and indirect methods, equations of motion via Langrangian approach, aerospace vehicle applications. Prerequisites: Undergraduate dynamics. Fall Quarter 4 credit hours

MECH 523 – Dynamics of Robotic Devices: The objective of this course is to provide an in-depth study of the dynamics of robotic devices, including manipulator arms and end-effectors. The dynamical equations are developed for open and closed chain robotic devices both in explicit form for analysis and recursive form for real time computation and simulation. Design factors that effect manipulator dynamic performance, such as decoupling and configuration invariance, are discussed. Screw theory is introduced to describe gripper performance. Symbolic software programs which generate the equation of motion are used by the student to support classwork. Prerequisites: MECH 423 or Permission of Instructor. Winter Quarter 4 credit hours

MECH 528 – Aircraft Stability: Derivation of aircraft equations of motion, including determination of aerodynamic forces and moments. Trim conditions, linearization of the aircraft equations and stability analysis. Longitudinal and lateral modes of motion. Prerequisites: MECH 423 and AERO 535. 3 credit hours

MECH 529 – Dynamics and Control of Flight Vehicles: Aerodynamic consideration of lift, drag and moment. Aerodynamic stability derivatives. Derivation of the aircraft equation of motion. Trim conditions and stability analysis of the linearized equation of motion. Prerequisites: MECH 521. Winter Quarter 4 credit hours

MECH 532 – Introductory Space Flight Dynamics: Formulation and solution of the two-body problem in three dimensions. Orbital elements, reference frames, coordinate transformations, orbit determination methods, basic orbital maneuvers. Formulation and description of basic attitude dynamics and control concepts, including spin-, dual-spin, three-axis, and gravity gradient stabilization. Prerequisites: Undergraduate dynamics or permission of instructor. Winter Quarter 3 credit hours

MECH 533 – Intermediate Space Flight Dynamics: Rigorous development of equations of motion of a rigid body in a gravitational field. Decoupling the translational and rotational equations of motion. Ballistic missile and interplanetary trajectories. The three-body problem and perturbation methods. Analysis of important problems in attitude dynamics and control, including reorientation, despin, control moment gyros, and reaction wheel systems. Introduction to attitude determination methods. Prerequisites: MECH 423 and MECH 532. Spring Quarter 3 credit hours

MECH 541 – Mechanics of Composite Materials: Introduction to the analysis of composite materials. The nature and scope of composite materials are discussed as well as mechanical behavior. Micromechanics, macromechanics, and characterization of composite materials are presented.

Emphasis is placed on gaining a basic understanding of composite materials behavior from both the applied mechanics and materials science aspects. Prerequisites: MECH 500. Winter Quarter 4 credit hours

MECH 556 – OPTIMAL PERFORMANCE: Trajectory equations for flight vehicles over a spherical and flat earth. Application of quasi-steady aircraft performance for both subsonic and supersonic flight. Optimization of functions of several variables with equality and inequality constraints. Introduction to the calculus of variations, energy maneuverability. Introduction to optimal control. Prerequisites: MECH 528. 4 credit hours

MECH 581 – INTRODUCTION TO CAD-CAE: An introduction to the concepts and applications of Computer Aided Design (CAD) and Computer Aided Engineering (CAE). Use of graphics software in the AFIT computer environment such as SDRC-IDEAS to model three-dimensional bodies. Advanced concepts of display manipulation to obtain desired presentation. Use of preprocessors to convert CAD model to finite element model for CAE. Application of analysis programs such as MSC/NASTRAN and post-processing of data. Finite element mass and stiffness matrices. Contour plotting, x-y plotting. Prerequisites: Permission of Instructor. Fall Quarter 2 credit hours

MECH 600 – ELASTICITY: A review of linear, infinitesimal continuum theory. Introduction to nonlinear elasticity. Solutions in curvelinear coordinate problems. Introduction to plate theory. Buckling and instability. Prerequisites: MECH 500. Winter Quarter 4 credit hours

MECH 605 – FRACTURE MECHANICS: The course is designed to acquaint students with analytical and experimental techniques used to solve current fracture problems. Specific course objectives are to develop the linear elastic fracture mechanics principles which allow one to predict the critical crack size for a given component (i.e., predict fatigue crack growth, stress corrosion cracking, etc.). The role fracture mechanics can play in assuring fracture prevention is discussed, with emphasis on current USAF requirements. Prerequisites: MECH 500 or Permission of Instructor. Spring Quarter 4 credit hours

MECH 610 – STRUCTURAL VIBRATIONS: Vibration of continuous systems; strings, rods, bars, membranes and plates. General formulation of the eigenvalue problem. Emphasis on variational methods and approximate methods of solution. Series methods, Fourier transform methods and Green's functions. Prerequisites: MECH 515; MECH 500; MATH 513 or SENG 525; MATH 511 or MATH 611. 4 credit hours

MECH 611 – RANDOM VIBRATIONS: Review of probability theory. Autocorrelation and power spectral density function of a single-degree of freedom system and multi-degree of freedom systems. Fatigue due to random vibrations. Prerequisites: MECH 515 or SENG 525; STAT 601 or calculus based probability course. 4 credit hours

MECH 620 – SYSTEMS OPTIMIZATION: This course covers theory and procedures for optimizing multivariable, non-linear objective functions that measure system performance. Topics include: formulation of classical and Kuhn-Tucker optimality conditions; numerical algorithms for solving classes of problems - linear programming, gradient and simulated annealing search techniques for nonlinear problems, multiobjective optimization theory; and special topics illustrated with problems in aerospace design. Prerequisites: MATH 511 and Computer Programming. Spring Quarter 3 credit hours

MECH 622 – FUNCTIONAL OPTIMIZATION AND OPTIMAL CONTROL: Variational techniques are applied to optimize linear and nonlinear dynamic systems with respect to prescribed inequality constraints are considered. Optimization of functionals using the calculus of variations and Pontryagin's Maximum Principle, leading to the derivation and solution of the optimal control problem. Special topics include: "bang-bang" control, dynamic programming, terminal controllers and regulators, perturbation techniques and singular solutions. Prerequisites: SENG 565 or equivalent. Winter Quarter 4 credit hours

MECH 628 – AIRCRAFT CONTROL: Introduction to aircraft flight control systems. Response to control inputs. Use of classical control theory to analyze and design longitudinal and lateral autopilots. Digital computer techniques and response to random inputs. Prerequisites: MECH 528; SENG 565 or equivalent. Spring Quarter
4 credit hours

MECH 629 – AIRCRAFT HANDLING QUALITIES AND PERFORMANCE: This course presents an overview of aircraft performance and handling qualities. Topics covered in performance include climb, cruise, and turn performance. The flying qualities portion includes aircraft dynamics, classical aircraft handling qualities, parameters, pilot modeling, pilot ratings and their prediction. Prerequisites: MECH 528 or MECH 529. Summer Quarter
4 credit hours

MECH 636 – ADVANCED ASTRODYNAMICS: Introduction to canonical dynamics and applications to the two body problem. Classical and canonical variation of parameter equations of motion. Forces influencing earth satellite motion are surveyed. Applications to earth satellite motion. Additional topics from resonance, stability, periodic motion. Prerequisites: MECH 720. Spring Quarter
4 credit hours

MECH 637 – ASTRODYNAMIC RE-ENTRY: Introduction to planetary atmospheres and aerodynamic forces. Equations for flight over a spherical planet. Performance in extra-atmospheric flight. Return to atmosphere. Basic equations for planar entry trajectories. Analysis of first-order planetary entry solutions. Loh's Second-Order Theory. Yaroshevskii's Theory. Chapman's Theory. Entry corridors. Unified theory of Re-Entry. Orbit contraction due to Atmospheric Drag. Prerequisites: MECH 532 and MECH 720. 4 credit hours

MECH 642 – FINITE ELEMENT METHODS FOR STRUCTURAL ANALYSIS I: Energy principles. Stiffness analysis of structural members. Formulation of structural problems using finite element methods. Analysis of trusses, frames, plane stress and plane strain problems. Prerequisites: MECH 500 and Computer Programming. Spring Quarter 4 credit hours

MECH 644 – FINITE ELEMENT METHODS FOR STRUCTURAL ANALYSIS II: Advanced topics in finite elements techniques. Formulation and solution of the system equations. Application to free forced response, stability, and nonlinear analysis. Prerequisites: MECH 642; MECH 600 or MECH 515. Summer Quarter 4 credit hours

MECH 646 – STRUCTURAL OPTIMIZATION: General formulation of optimal design. Approaches to structural design and optimization. The min-max problem. Direct and indirect methods. Multicriterion optimization. Prerequisites: MECH 500.
4 credit hours

MECH 662 – INTRODUCTION TO AEROELASTICITY: Mathematical foundations of aero-elasticity. Static aeroelastic behavior of swept and straight wings, control surface effectiveness, coupled control surface/wing torsional divergence. Free vibration and dynamic response of continuous systems. Unsteady, quasi-steady aerodynamics in subsonic and supersonic regimes. Nonconservative dynamic instability, fluttering systems. Prerequisites: MECH 515 and AERO 535.
4 credit hours

MECH 701 – INELASTIC MATERIAL BEHAVIOR: An introduction to mathematical models descriptive of the behavior of real engineering materials. Topics include the elements of cartesian tensors, conservation laws for continua, theory of constitutive relationships, yield criteria, plastic stress strain laws, flow rules and work hardening; linear visco-elasticity, correspondence principle, creep and stress relaxation; and such thermal effects as thermoelasticity, thermoplasticity, and the time-temperature equivalence of thermorheologically simple materials. Prerequisites: MECH 500.
4 credit hours

MECH 704 – THEORY OF SHELLS: Differential geometry, development of theories for thin shells, considering both nonlinear and linear strain-displacement relations, static analysis of different shell surfaces with varying boundary conditions. Prerequisites: MECH 600. 4 credit hours

MECH 705 – ADVANCED FRACTURE MECHANICS: The course is designed to consider the advanced and current topics in Fracture Mechanics. Specific topics will include: crack tip stress analysis, power series solutions, analytic solutions, numerical methods. Energetics of cracked bodies. Elastic-plastic fracture mechanics, elastoplastic crack tip fields, engineering approach to plastic fracture, crack growth in an elastoplastic body. Dynamic fracture mechanics, fast crack propagation and arrest concepts. Fatigue, prediction of fatigue life, nonlinear aspects of fatigue crack propagation. Prerequisites: MECH 605.
4 credit hours

MECH 706 – PLASTICITY: Theory of isotropic plasticity, yield criteria, and plastic stress-strain relations; applications to elastic-plastic stress analysis in two and three dimensions; visco-plastic flow, creep in metals and the Bauschinger effect. Application of the finite element to physical problems. Prerequisites: MECH 600.
4 credit hours

MECH 707 – FUNDAMENTALS OF PLATES AND SHELLS: Bending and stretching of thin elastic plates under loading with various boundary conditions. General linear bending theory of shells with simplifications to the membrane theory; bending stress in shells of revolution, shallow shell theory. Application of finite elements and finite difference to the energy equations for plate and shell problems. Prerequisites: MECH 600. 4 credit hours

MECH 708 – ENGINEERING VISCOELASTIC ANALYSIS: Material characterization. Stress analysis. Failure and fracture. Applications, especially solid rocket motors. Prerequisites: MECH 500 and MATH 513.
4 credit hours

MECH 712 – NONLINEAR OSCILLATIONS: Liapunov's direct method. Nonautonomous systems, linear systems with periodic coefficients, Floquet theory. Perturbation techniques, secular terms, Linstedt's methods, KBM method. Prerequisites: MECH 720 or Permission of Instructor. Spring Quarter 4 credit hours

MECH 719 – VIBRATION DAMPING AND CONTROL: A survey course in vibration damping and control providing the necessary background to analyze structural vibrations and design effective and efficient vibration supression using either passive or active means. Topics covered include modal analysis, viscoelastic damping treatments, vibration absorbers, vibration isolators, and active feedback control using both traditional and adaptive structures technology. Method of instruction will include both lecture and laboratory sessions. Prerequisites: MECH 500, MECH 515, SENG 565 or Permission of Instructor. Summer Quarter
4 credit hours

MECH 720 – ANALYTICAL MECHANICS: Elements of the calculus of variations, virtual work, D'Alemberts' principle, Lagrange's and Hamilton's equations of motion; applications to holonomic and nonholonomic systems with emphasis on rigid body motion and gyroscopic instruments. Prerequisites: MECH 423. Winter Quarter
4 credit hours

MECH 722 – CONTROL OF FLEXIBLE SPACECRAFT: The mechanics and control of flexible spacecraft is studied. Rigid body control is reviewed first. Secondly, the design and analysis of both passive and active feedback control for vibration suppression in large flexible spacecraft systems include: multibody dynamics, eigenstructure assignment control, optimal projections control, collocated versus non-collocated control, and the simultaneous design of both active and passive control. Prerequisites: MECH 515, MECH 720 and SENG 665.
4 credit hours

MECH 723 – ADVANCED ROBOTICS: Use of kinematic redundancy in manipulator is considered to avoid joint singularities and limits and arm collisions and to optimize the performance characteristics of response time and energy. Linear algebra concepts are developed to priortize multiple tasks. Actuator redundancy in closed loop and in-parallel manipulators is considered. Force control concepts for unstructured environments are developed. Task space force control is introduced and the effects of noncolloca tion and multi-sensor fusion are examined. Application to flight control of aircraft and spacecraft is included. Prerequisites: MATH 521, SENG 525, EENG 540, or MECH 523. Spring Quarter 4 credit hours

MECH 725 – MAN-IN-THE-LOOP CONTROL: This course examines approaches that are being tried in various man-in-the-loop applications including remotely piloted vehicles, teleoperators, simulators, and interactive computer simulations. Issues examined include: bilateral and computer supplemented control strategies, appropriate levels of human intervention and remote autonomy in the system; impact on operator performance of data type, intensity, quality and display format; impact of time delay on stability; and procedures for evaluating man-in-the-loop systems. Laboratory projects provide experience in implementation of teleoperation concepts. Prerequisites: EENG 540; SENG 565 or undergraduate control course. Summer Quarter 4 credit hours

MECH 728 – ADVANCED FLIGHT MECHANICS: Advanced topics in flight mechanics and control chosen from: optimal control, discrete-data control systems, aeroelastic effects, human pilot models and nonlinear effects. Prerequisites: MECH 628; SENG 525 or equivalent. 4 credit hours

MECH 731 – MODERN METHODS OF ORBIT DETERMINATION: Introduction to probability theory. Statistical mission assessment. Derivation of the method of least squares in linear and nonlinear problems. Sequential estimation methods, including numerical instabilities and time weighting. Applications to the problem of determining and updating the orbital elements of satellites. Prerequisites: MECH 532. Summer Quarter 4 credit hours

MECH 741 – ADVANCED TOPICS IN THE MECHANICS OF COMPOSITE MATERIALS: Nonlinear displacement theory in plates and shells considering transverse shear effects. The energy techniques related to bending, buckling and vibrations of laminated plates and cylindrical shells. Environmental considerations in composite materials. Fracture mechanics and fatigue of composite structures. Prerequisites: MECH 541. 4 credit hours

MECH 742 – FINITE ELEMENT ANALYSIS IN FLUID MECHANICS AND HEAT TRANSFER: Formulation of the finite element method using variational principles and weighted residual techniques. The use and development of one and two dimensional elements. Applications to heat transfer and fluid mechanics in particular are considered. Prerequisites: MENG 571 or Permission of Instructor. 4 credit hours

MECH 825 – SPACECRAFT STABILITY: Passive and active control of space vehicles. Attitude dynamics of satellites, orbital force environment. Gravity gradient, dual spin and high spin satellites. Momentum wheels, reaction control jets and control moment gyros. Flexibility effects on control. Prerequisites: MECH 720 and MECH 712. 4 credit hours

MENG 431 – PROPULSION: Basic principles of fluid mechanics, thermodynamics and gas dynamics are studied and then applied to the analysis of propulsion systems and their components. Ramjet, turbojet, and turbofan systems are analyzed. Performance trade-offs are reviewed relative to military systems. Prerequisites: Undergraduate Thermodynamics. Fall Quarter 3 credit hours

MENG 530 – Chemical Rocket Propulsion: Development of performance parameters, analyses of combustion, fluid mechanics, and heat transfer as they pertain to rocket engines and motors, comparison of propellants, and analysis of simple rocket flight and staging. Prerequisites: Undergraduate Thermodynamics. Winter Quarter 4 credit hours

MENG 531 – Space Propulsion and Power Systems: Concept, theory and performance of chemical and nonchemical propulsion systems for use in space. Typical Systems will include electrical, nuclear, liquid propellant, and exotic space propulsion systems. Concept, theory and performance of power generation methods in space. Systems studied will include low and high power systems intended for short term or long term applications. Chemical, solar and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power will be studied. An overview of space mission requirements and how they impact propulsion and power system selection. Review of current and future trends in spacecraft propulsion and power generation. Prerequisites: None. Spring Quarter 4 credit hours

MENG 532 – Space Power Systems: Space power systems that will be considered include low power and high power systems intended for short term or long term applications. Chemical, solar, and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power will be studied. Prerequisites: None. 4 credit hours

MENG 571 – Fundamentals of Heat Transfer: Fundamentals of conduction, convection and radiation heat transfer. Derivation and solution of the general heat conduction equation for one and two dimensional, steady and unsteady conduction problems. Both analytical and numerical solution techniques will be covered. Forced convection in laminar and turbulent flows on internal and external surfaces. Radiation heat transfer among surfaces. Application to thermal processes in a variety of systems. Prerequisites: Undergraduate Thermodynamics. 4 credit hours

MENG 630 – Fluid Mechanics of Rockets: Compressible fluid flow, supersonic linearized flow, two-dimensional supersonic flow in rocket nozzles, method of characteristics, shock wave theory, oblique shocks, liquid propellant rocket flow systems, flow in propellant feed systems, and unsteady flow concepts. Prerequisites: Undergraduate Fluid Mechanics and MENG 530. 4 credit hours

MENG 631 – Solid Propellant Rockets: The course covers interior ballistics of solid rocket motors, solid propellant grain design, heat transfer, burn mechanisms, nozzles, thrust vectoring and termination, and motor structural design considerations. Prerequisites: MENG 530 or Permission of instructor. 4 credit hours

MENG 632 – Non-Chemical Propulsion: Concept, theory, and performance of electrical, nuclear, and exotic space propulsion systems. Includes space mission requirements, power generation in space (energy sources and conversion), and comparison and selection of propulsion systems for use in space. Prerequisites: MENG 530 or Permission of Instructor. 4 credit hours

MENG 633 – FUNDAMENTALS OF COMBUSTION: This course is designed to provide an understanding of the fundamentals of combustion and combustion aerodynamics. Topics include: (1) Chemical thermodynamics: heats of reaction and flame temperature; (2) Chemical kinetics: rates of reaction, reaction order, chain reactions, and explosions; (3) Gas dynamics of reacting flows; (4) Deflagration and detonation of premixed gases: the Hugonoit Curve; (5) Laminar flames; and (6) Turbulent flames. This course is designed to strengthen both the Air Breathing and Rocket propulsion sequences by providing a detailed analysis of combustion processes. Prerequisites: Thermodynamics, Chemistry, and Differential and Integral Calculus.
4 credit hours

MENG 634 – HYPERSONIC AIRBREATHING PROPULSION: Fundamentals of hypersonic vehicle propulsion with emphasis on the scramjet cycle and understanding the problems of supersonic combustion and mixing. Topics include a review of hypersonic aerodynamics, high speed viscous effects, and thermochemistry including chemical equilibrium and kinetics. Elements of vehicle integration and component design will be discussed. Prerequisites: AERO 536; MENG 431; MENG 571 or equivalent.
4 credit hours

MENG 673 – RADIATION HEAT TRANSFER: Study of methods for calculating heat transfer by thermal radiation. Integral equations are formulated for thermal radiation among surfaces with and without an intervening gas. Approximate engineering methods of solution are emphasized and applied to components of satellite, propulsion, and solar energy systems. Prerequisites: MENG 571 or equivalent.
4 credit hours

MENG 674 – CONVECTION HEAT TRANSFER: Differential and integral analyses of laminar and turbulent convection heat transfer. Forced convection in internal flows, including entrance regions. Forced convection in external flows, from low to supersonic speeds. Free convection. Applications to heat exchangers, environmental control and thermal protection systems. Prerequisites: MENG 571 or equivalent. 4 credit hours

MENG 732 – ADVANCED TURBOMACHINERY: The principles of fluid mechanics, thermodynamics, heat transfer, and combustion are applied to gas turbine engines. Cycles and component performance are covered with emphasis on application in high performance aircraft propulsion systems. Prerequisites: MENG 431 or Permission of Instructor. Spring Quarter 4 credit hours

MENG 733 – AIRBREATHING ENGINE DESIGN: The laws of mechanics and thermodynamics are applied to determine the design point requirements for and the design of an aircraft gas turbine engine. Emphasis is placed on determining the engine type best suited to the requirements of a specified aircraft mission. Computer analysis is used extensively in mission analysis, on-design and off-design engine performance analysis, and in component design. Prerequisites: MENG 732 or Permission of Instructor. Summer Quarter 4 credit hours

SYSTEMS ENGINEERING

SENG 505 – INSTRUMENTATION AND MEASUREMENT LAB: An introduction to instrumentation and procedures used in measurement systems. Includes measurement of static and dynamic response of solids, fluids and thermal processes. Includes a group project specifically aimed at the student's thesis area. Prerequisites: None.
3 credit hours

SEENG 516 – INTRODUCTION TO INSTRUMENTATION: An introduction to instruments and systems with an emphasis toward experimental research. Topics include: instrument theory; static characteristics and error analysis; dynamic characteristics and instrument response to steady, periodic, transient and random inputs; impedance, transducer and read out concepts, modeling of instruments and systems; analog and digital filtering, operational amplifiers, digital data acquisition, introduction to Fast Fourier Transform. Prerequisites: Undergraduate circuit theory. Summer Quarter 2 credit hours

SENG 520 – SYSTEMS ENGINEERING DESIGN: This course provides a broad introduction to the structured approach necessary for the design of complex systems. The formulation of systems problems and the approach to their solution will be emphasized. Basic mathematical techniques available to the systems engineer are presented. The design process will be illustrated through the review of past design efforts, and the application to a problem of current interest. Prerequisites: None.Winter Quarter 3 credit hours

SENG 525 – LINEAR SYSTEMS ANALYSIS: This course covers the underlying theory of linear time invariant and time varying dynamic systems. The modeling of engineering systems, including mechanical, electrical, fluid, and thermal systems, is covered. Analysis techniques include classical analysis in the time and frequency domains, and modern state space techniques for linear systems. Course is now combined with EENG 510. Prerequisites: None. Fall Quarter 4 credit hours

SENG 530 – INTRODUCTION TO SPACE PROGRAMS AND OPERATIONS: This course examines the history and current status of military space operations. Topics include the history of space flight, the relationships between military and civil space programs, space law, US space policy, military space missions, US military space organizations, and non-US space programs. Introduction to standard space mission analysis software. Prerequisites: Permission of instructor. Fall Quarter 3 credit hours

SENG 535 – SPACE INTELLIGENCE SEMINAR: This course is designed to provide the student with a picture of worldwide space activities, with an emphasis on military space operations. Seminars will include classified presentations by intelligence analysts. Subjects covered will include operational and technical aspects of US and foreign space systems and related topics of DoD interest. Prerequisites: Permission of instructor. Fall, Spring, and Summer Quarters 0.5 credit hours

SENG 563 – TERMINAL EFFECTS AND DELIVERY OF CONVENTIONAL WEAPONS: This course provides the analytical basis for computing delivery trajectories and terminal effects of conventional weapons. It covers such topics as vacuum trajectories and atmospheric trajectories, powered trajectories, and projectile stability. Terminal effects are quantified and related to potential targets and their damage criteria. The following terminal effects topics are studied in some detail: chemical explosives and blast waves, guns and projectiles, fragmentation warheads, projectile impact, target hardness, armor penetration, shaped charge weapons, and explosively formed fragments. Prerequisites: Undergraduate Dynamics. 4 credit hours

SENG 564 – CONVENTIONAL WEAPONS EFFECTS: This course provides a basis of understanding the analysis of effectiveness of conventional weapons against air and ground targets. It includes a study of several conventional damage mechanisms, conventional explosives and projectile and fragment trajectories. Weapons effects and target survivability are discussed. Types of warheads and delivery systems are described. Some techniques for enhancing survivability will be examined relative to hardening aircraft and decreasing susceptibility to being acquired, tracked, and fired upon. Prerequisites: Basic Mechanics and Thermodynamics. Summer Quarter
4 credit hours

SENG 565 – CONTROL AND STATE SPACE CONCEPTS: This course covers topics in conventional and modern control theory. The interrelation between conventional and modern approaches is emphasized. Topics include: feedback system analysis; root locus, Bode, and Nyquist analysis; state feedback control and observers; control system compensation design. Prerequisites: SENG 525 or equivalent. Winter Quarter 4 credit hours

SENG 581 – SURVIVABILITY AND VULNERABILITY OF SYSTEMS: The fire control problem is introduced and various guidance laws are analyzed. Sensor and fuse functions are discussed. The analysis of weapon delivery errors is presented. Vulnerability analysis to non-nuclear threats, kill definitions and criteria, vulnerable areas and volumes, and relations to threat type are discussed. Susceptibility is defined and illustrated. Survivability enhancement techniques; reduction of observables, performance factors, hardening, etc., are presented. Design trade-offs and case studies are considered. Prerequisites: SENG 563. 4 credit hours

SENG 585 – RELIABILITY IN SYSTEMS DESIGN: The purpose of this course is to introduce students to the probalistic models and statistical methods used by reliability engineers. This first course gives basic definitions and terminology, investigates parametric lifetime models, non-parametric methods, coherent systems analysis. Markov analysis techniques and an introduction to repairable systems analysis. Emphasis will be placed on using these mathematical tools to model RAM as a dynamic process, develop test plans, perform graphical and statistical inference, as well as model product improvement in the development process. Prerequisites: None.
4 credit hours

SENG 586 – ENGINEERING DESIGN FOR RELIABILITY: Concepts of probability theory applied to fundamental design. Concentration on static design with introduction to techniques for dynamic systems. Topics include statistical tolerancing, interference theory, Monte Carlo analysis techniques, and various first order second moment methods. Methods for systems with time varying stress or strength characteristics will be introduced. Although emphasis is on structural/mechanical elements, application to other engineering fields will be presented. Prerequisites: STAT 601. 4 credit hours

SENG 620 – TOPICS IN SYSTEMS ENGINEERING: This course builds on the material presented in SENG 520, presenting the theoretical foundations for many topics in systems sciences. Topics vary but generally include finite state machines, Wymore's tricotyledon theory, catastrophe theory, chaos, and General Systems Theory. Additional topics may be covered as time and interest permit. Prerequisites: None. Summer Quarter 3 credit hours

SENG 625 - Non-linear Systems Analysis and Control: This course serves as an introduction to the fundamental results of modern nonlinear control. The first half of the course will concentrate on the analytical tools that can be used to study a non-linear system. Specific topics in this area are phase-plane analysis, stability and Lyapunov theory, perturbation methods and describing functions. The second half of the course will cover several nonlinear control synthesis techniques such as feedback linearization, sliding mode, and model reference adaptive control. Examples will be drawn from air and space applications. Prerequisites: SENG 525, 565 or equivalent. 4 credit hours

SENG 631 – Spacecraft Systems Engineering: This course provides a detailed introduction to the design of complex space systems. The key elements and subsystems of several important classes of space systems are presented. The systematic approach necessary to effectively design space systems is illustrated through case studies. Individual or group design projects are conducted and presented. Prerequisites: SENG 520, MECH 532 and MECH 533 or permission of instructor. Summer Quarter
4 credit hours

SENG 639 – Systems Design Project: This course provides a capstone system design experience for students who are not doing a systems design thesis. It will emphasize the practical details of applying systems engineering tools and techniques to a real multi-disciplinary design problem. Students will be assigned to small design teams and given a general problem statement. The team will be responsible for completing a thorough systems analysis of the problem, developing and evaluating alternative solutions, selecting the best alternative, proposing appropriate implementation of the selected solution, and documenting the entire experience. Students will also receive supplementary instruction covering details of the design process and new tools and techniques relevant to the selected projects. Prerequisites: SENG 520.
Summer Quarter 4 credit hours

SENG 665 – Multivariable Control Theory: This course covers the principles of linear multivariable control systems. Topics studied include the theory of full state and reduced order regulator and estimators. Multivariable Nyquist Stability Criteria, LQG control theory, eigenstructure assignment theory, tracking control and an introduction to multivariable digital control analysis. Prerequisites: SENG 525 and SENG 565 or EENG 510 and EENG 562. Spring Quarter
4 credit hours

SENG 685 – Reliability Engineering: This course is a continuation of SENG 585. This course introduces the students to some advanced reliability modeling and statistical analysis techniques. The student will be introduced to a variety of statistical inference procedures. Topics include sequential procedures, Bayesian procedures, and parameter estimation with covariates. Some of the specialized reliability models introduced in SENG 585 will be examined in more detail. In particular, competing risks, accelerated life, and proportional hazard models will be discussed. The final third of the course will focus on strategies currently being used to optimize the design of systems using the most cost effective combination of design parameters under uncertainty. Electrical circuits, mechanical structures, and manufacturing processes will be used as examples. Prerequisites: STAT 601 and SENG 585. 4 credit hours

SENG 687 – ADVANCED TOPICS IN RELIABILITY: The objective of this course is to introduce students to advanced topics in systems design in the area of reliability, maintainability, and availability applied to system design. Comparison of current Eastern/Western approaches to design is focus of course. Emphasis is on the application of design of experiments to improve quality of complex systems. Prerequisites: SENG 685 and STAT 601 or Permission of instructor.
4 credit hours

SENG 765 – ROBUST CONTROL: This course covers robust control theory and applications. The emphasis is on a unified theory in which performance and robustness to plant uncertainties and/or input disturbances are handled directly. Modeling of uncertainty is covered, and signal and transfer function norms are used to quantify both the levels of uncertainty and robustness to it. Lyapunov and Riccati theory is treated in detail, as well as the concepts of parameterizing all stablilizing compensators, linear fractional transforms, linear matrix inequalities, and Hamiltonian matrices. The H-2, H-infinity and mu-synthesis techniques are covered, and relevant examples from air and space systems will be used to demonstrate applications of these techniques. Prerequisites: SENG 665 (Multivariable Control). Summer Quarter 4 credit hours

SENG 766 – CURRENT TOPICS IN ROBUST CONTROL: This is an advanced course that follows the foundation laid in SENG 765. Continuing along the "post-modern" control theory approach, the basic ideas of H-2 and H-infinity optimization are expanded and refined. In particular, the course will cover such topics as: mixed objective optimal control (such as H-2/H-infinity), mu-synthesis, L-1 optimization, and direct reduced order control. The basic objective of this course is to update the student to the current state-of-the-art in linear control theory. Prerequisites: SENG 765.
4 credit hours

SENG 799 – GROUP DESIGN STUDY: A design study on a topic of current Air Force interest (which may be classified) is selected as a class project. The class develops its own organizational structure to suit the problem, develops a statement of work and conducts the study. Progress reports and final reports are given to the sponsoring organization, as required. A formal written report is prepared by the group and accepted by the faculty in lieu of the Master's thesis. This course extends over four quarters and no credit is given until the end of the last quarter. Corequisite: Enrolled in Systems Engineering Program.
12 credit hours

Department of Electrical and Computer Engineering

Department of Electrical and Computer Engineering
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Department Head: Colonel Thurmon L. Deloney II

Introduction

The Department of Electrical and Computer Engineering is home to the graduate programs in Electrical Engineering, Computer Engineering, and Computer Science. An interdisciplinary department, its faculty holds a broad range of expertise in the fields of communications, radar, stealth technology, guidance, navigation, flight control systems, the Global Positioning System (GPS), signal and image processing, electro-optics, microelectronics, micro-electro-mechanical systems (MEMS), very large scale integrated (VLSI) circuits, information assurance and security, computer engineering, software engineering, data mining and fusion, parallel computing, and satellite networks.

Faculty

Professors

Gary B. Lamont (evolutionary computing, parallel computing)

James A. Lott (microelectronics, photonics, MEMS)

Peter S. Maybeck (guidance, navigation, control, stochastic processes)

Meir Pachter (flight dynamics and control, inertial and GPS navigation)

Henry B. Potoczny (computer and data security, cryptography)

Vittal P. Pyati (electromagnetics, radar, electronic warfare)

Associate Professors

Stephen C. Gustafson (optical and signal processing, pattern recognition)

Richard A. Raines (satellite communications and networks)

Andrew J. Terzuoli (antennas, electromagnetics, stealth technology)

Assistant Professors

Rusty O. Baldwin (wireless networks, protocols, communications)

Charles P. Brothers, Jr. (VLSI, space electronics, computer architecture)

Roger L. Claypoole (signal and image processing, pattern recognition)

Thurmon L. Deloney II (ballistic missile defense, high-power lasers)

Gregg H. Gunsch (data assurance, data security, information warfare)

Timothy M. Jacobs (computer graphics and engineering)

Paul E. Kladitis (MEMS)

Eric P. Magee (electro-optics, space surveillance, laser radar)

Karl S. Mathias (software visualization, computer simulations)

Mikel M. Miller (GPS, guidance, navigation, and control)

John F. Raquet (precision differential GPS, jamming detection/mitigation)

Michael A. Temple (communication systems, electromagnetics)

William Wood (electromagnetics, radar, stealth technology)

Emeritus Faculty

John J. D’Azzo (guidance, navigation, and control systems)

Thomas C. Hartrum (computer database systems, software engineering)

Constantine H. Houpis (guidance, navigation, and control systems)

Programs of Study

Electrical Engineering (GE)

The Graduate Electrical Engineering (GE) program is designed to develop competence in a wide range of areas of electrical engineering that are of interest to the Air Force. Applicants for the Graduate Electrical Engineering program should hold an ABET-accredited Bachelor of Science degree in electrical engineering.

Students pursuing programs in electrical engineering have options in the following seven areas with the associated core courses:

- Communications (EENG 530, EENG 580, EENG 669)
- Digital Engineering (CSCE 593, CSCE 687, CSCE 689, CSCE 692)
- Electromagnetics (selected among the following: EENG 524, EENG 625, EENG 627, EENG 628, EENG 630, EENG 631, EENG 725, EENG 726, EENG 727),
- Low Observables (EENG 524, EENG 535, EENG 627, EENG 630)
- Microelectronics (PHYS 570, EENG 675, EENG 717)
- Guidance, Navigation, and Control (EENG 562, EENG 765, EENG 766 and EENG 768 or one of the following - EENG 712, EENG 655, EENG 708)
- Signal Processing (EENG 580, EENG 680, EENG 681)

Areas of specialization include lasers and electro-optics; VLSI/VHSIC; target recognition; radar, antenna, and microwave engineering; control applications; optical space surveillance and beam control; and computer and software engineering.

Computer Engineering (GCE) and Computer Science (GCS)

The GCE and GCS programs are designed to develop competence in a wide range of areas of computer engineering, computer systems, and computer science. Applicants for the Graduate Computer Engineering program should hold an ABET-accredited Bachelor of Science degree in electrical engineering (with a digital emphasis) or computer engineering. Applicants for the Graduate Computer Systems program should hold a degree in computer science, mathematics, or one of the physical sciences (with a strong background in computer science).

Students pursuing a degree in computer engineering (GCE) are required to enroll in the following core courses: CSCE 586, CSCE 593, CSCE 687, CSCE 692, and either CSCE 689 or CSCE 654. Emphasis is placed on the design and development of hardware and software systems, their integration, and their application.

The GCS program currently has two major areas: Computer Systems and Computer Science. Students meeting the general GCS program requirements qualify for the Computer Systems major. The Computer Science major is oriented towards a stronger theoretical understanding, and requires a predetermined set of mathematics and theory courses. The core course requirement for the computer systems major includes CSCE 586, CSCE 593, and either CSCE 689, CSCE 654, or CSCE692. The computer science major requires the student to enroll in CSCE 593 and either CSCE 689 or CSCE 692 to meet the core requirements.

The student can select courses from among the following areas that define a particular specialization:

- Communication Systems
- Artificial Intelligence
- Computer Networks
- Database Systems
- High Performance Computing
- Information Systems Security/Assurance
- Information Visualization
- Numerical Analysis
- Software Engineering

Doctor of Philosophy (Ph.D.) Program

The Department of Electrical and Computer Engineering offers studies leading to the award of a Ph.D. with a concentration in electrical engineering, computer engineering, or computer systems.

Facilities

The Department operates an extensive complex of laboratory and computing facilities for use by students and faculty in support of its academic and research programs in the areas of electrical and computer engineering and computer systems. These laboratories include:

- Communication/Radar Laboratory
- Communications OPNET Modeling and Simulation Laboratory
- Instrumentation Guidance, Navigation, and Control Laboratory
- Parallel Computing Laboratory
- Signal and Information Processing Laboratory
- Laboratory for Information Systems Security/Assurance Research and Development
- VLSI Design Laboratory
- Microelectronics Clean-room and Device Characterization Laboratory
- Micro-Electro-Mechanical Systems (MEMS) Laboratory
- Microwaves Laboratory
- Radar Cross Section (RCS) Laboratory
- Pattern Recognition Laboratory

Research

The Department of Electrical and Computer Engineering is home to an interdisciplinary faculty with a wide variety of Air Force relevant research interests in the fields of electrical engineering, computer engineering, computer systems, bioengineering, aerospace engineering, applied physics, and electro-optics. Master’s and doctoral-level research programs are critical components of the Graduate School experience. Areas of recent interest include photonics, nanotechnology, the Global Positioning System, flight control of aerospace vehicles, radiation hardened space electronics, military information operations, stealth technology, computer data mining and fusion, evolutionary algorithms for military systems, and satellite networks for global command and control systems.

Course Offerings

COMPUTER SCIENCE AND ENGINEERING

CSCE 431 - Fundamentals of Discrete Mathematics: An introduction to discrete mathematics for computer scientists and engineers. Basic concepts and terminology are presented along with examples from the different computer science specializations. Topics include: logical reasoning; methods of proof; sets, relations, and functions; summation and recurrence relations; counting; and an overview of graph theory. Prerequisites: None. Fall Quarter 4 credit hours

CSCE 486 - FUNDAMENTALS OF DATA STRUCTURES AND PROGRAM DESIGN: This course introduces the principles and methodologies used to design and implement small programs. The key principle of using hierarchical approaches to problem solving and program design is stressed as well as the importance of disciplined programming styles and program analysis techniques. Two critical parts of program design and implementation are the selection of the data structures used in the design and the programming language used to implement the program design. This course covers several of the basic data structures and demonstrates how data structure selection impacts program efficiency and maintainability. Additionally, the key features of structured and object-oriented programming languages such as data types, decision structures, and modularity will be covered. Several programming projects using a high-level programming language will be assigned to demonstrate the principles, methodologies, and data structures covered in this class. Prerequisites: None. Corequisite: CSCE 286. Fall Quarter 4 credit hours

CSCE 487 - INTRODUCTION TO DIGITAL SYSTEMS DESIGN: This course provides students with the background to design, develop, and test digital circuits for integration into a microprocessor-based computer system. The students will use the VHSIC Hardware Description Language (VHDL) and digital logic simulation tools to support laboratory projects. Emphasis is placed on the top-down design starting with a pure behavioral model of the problem, decomposing it, using design tools to simulate the model, and then implementing the model. Prerequisites: Undergraduate digital logic course. 4 credit hours

CSCE 488 - FUNDAMENTALS OF LOGIC DESIGN: This course is intended to provide students with the necessary background for more advanced work in design and application of digital computers. A systematic development of switching theory, logic network synthesis, and formal description of digital system functions develops the tools needed to analyze, evaluate, and design digital control and data processing machines. Topics include two-valued Boolean algebra, combinational and sequential logic network design, and Register Transfer Language (RTL). A project laboratory illustrates key concepts. Prerequisites: Permission of Instructor. 4 credit hours

CSCE 489 - OPERATING SYSTEMS: This course is an introduction to the concepts and principles of computer operating systems with emphasis on memory management, processor management, I/O management and system file structures. The objective is to give the student an understanding of operating systems and the necessary skills to evaluate and tradeoff desirable features of operating systems given specific user and resource requirements. The student will learn to develop and apply models in order to evaluate the performance of specific algorithms and the effect of algorithms on overall computer system performance. Case studies of current operating systems will be utilized to illustrate the application of the concepts and principles studied. Prerequisites: None. Corequisites: CSCE 486 and CSCE 488. Fall Quarter 4 credit hours

CSCE 492 - COMPUTER SYSTEMS ARCHITECTURE: The objective of this course is for students to understand the basic principles of a Von Neumann computer architecture. Emphasis is placed on how a processor and its control unit, memory, and input/output devices are organized, and how they interact to form a computer system. Specific topics covered in the course include instruction set design, computer arithmetic, pipeline design, memory hierarchy, natural memory, and input/output. Prerequisites: CSCE488. Fall Quarter 4 credit hours

CSCE 523 - ARTIFICIAL INTELLIGENCE: This course presents the major principles and techniques of artificial intelligence. Specifically, in-depth studies of core issues such as knowledge representation and problem identification, formulation, and solving are pursued. Topics include knowledge-representation (models of logic, predicate calculus, production-rules, semantic networks, symbolic and sub-symbolic representations), problem-solving (search, theorem-proving, reasoning), and knowledge-based systems (expert systems, natural language processing, vision, planning). Prerequisites: None. Corequisites: CSCE 531 and CSCE 586. Spring Quarter 4 credit hours

CSCE 525 - INTRODUCTION TO INFORMATION WARFARE: This seminar course defines Information Warfare (IW) and its ramifications for information security and assurance. It provides a foundational understanding of C4ISR (command, control, communications, computing, intelligence, surveillance and reconnaissance), the relationship of EW (electronic warfare) to C2W (command and control warfare) and IW, active and passive IW, information operations, deception and PSYOPS. Simultaneously, it engenders a systems-oriented viewpoint while examining Air Force, DOD, and national information infrastructures, their vulnerabilities, interdependencies and opportunities for exploitation. Prerequisites: None. Winter Quarter

2 credit hours

CSCE 531 - DISCRETE MATHEMATICS: This course provides more in-depth coverage, analysis, and application of set theory, binary relations, functions, and first-order predicate calculus from CSCE 431. Specifically, more emphasis is placed on applying predicate calculus and practice doing proofs, both deductive and inductive, formal proofs and informal proofs. New topic areas include: set countability and resolution-based theorem proving. This course also provides detailed and varied examples of how discrete mathematics is applied in other graduate courses in computer science and engineering. Prerequisites: CSCE 431. Fall and Winter Quarters

4 credit hours

CSCE 532 - AUTOMATA AND FORMAL LANGUAGE THEORY: The objective of this course is to prepare the student with a basic foundation in the concepts of automata and formal language theory. Topics covered will include Turing machines, finite state automata, combinatorics, and formal language theory. Prerequisites: None. Corequisites: CSCE 431, CSCE 531. Winter Quarter

4 credit hours

CSCE 544 - DATA SECURITY: This course presents the rudiments of data security. The emphasis is on cryptography, beginning with simple ciphers, and extending to public key cryptography based on sophisticated number-theoretic considerations. Other topics include key management, access controls and inference controls. Prerequisites: None. Spring Quarter

4 credit hours

CSCE 546 - INTRODUCTION TO DATABASE SYSTEMS: This course introduces the concept of a Database Management System (DBMS), types of database models, application of database systems, and various components of a DBMS. The objectives of the course are to develop an understanding of the theoretical underpinnings, uses, capabilities, advantages, and disadvantages of DBMSs; an understanding of the organization and manipulation of data in the types of DBMS available today; and an understanding of database design. A comprehensive set of laboratory exercises leads the student through the design and manipulation of a database using a commercially available DBMS, and remote database access via JDBC, ODBC, and active server pages. Prerequisites: None. Corequisites: CSCE 531 or permission of instructor. Winter Quarter

4 credit hours

CSCE 550 - SPECIAL TOPICS IN ELECTRICAL AND COMPUTER ENGINEERING: This course is based upon the introductory treatment of the development and application of electrical and computer engineering concepts to current DoD problems. The students will be exposed to one or more specific engineering concepts and complementary research applications with emphasis placed on discussions of system architectures including both hardware and software, distributed intelligence, data structures, modeling and simulation, information systems, and other inter-disciplinary topics. The laboratory for this course is an intensive individual research project tailored to the interests of the student availability of on-going departmental engineering research efforts. Prerequisites: Permission of Instructor. 4 credit hours

CSCE 554 - PERFORMANCE ANALYSIS OF COMPUTER SYSTEMS AND NETWORKS: The purpose of this course is to present practical techniques for the measurement, simulation, and analysis of computers and networks. A systematic approach to performance evaluation is developed. An important aspect of performance analysis is the presentation of measured data. This course will show how to use measured data to compare systems using elementary statistics and confidence intervals. Experimental designs such as single and multiple-factor experiments, full-factorial, and fractional factorial designs are presented. Other topics include selection and characterization of workloads, practical simulation techniques, random-variate generation, and development of regression models. Prerequisites: MATH 583 or background in elementary probability and statistics. Winter Quarter
4 credit hours

CSCE 582 - COMPUTER GRAPHICS I: This course is designed as a medium-paced, practical introduction to 2D and 3D computer graphics (CG) and its use in virtual environments. The course emphasizes a balance between traditional CG educational topics and labs topics devoted to familiarizing the student with current software tools for generating CG images and virtual environments. Prerequisites: CSCE 200. 4 credit hours

CSCE 586 - DESIGN AND ANALYSIS OF ALGORITHMS: This course emphasizes the structure of data and the efficient and effective manipulation (algorithms) of such structures. Physical and logical organization of data is discussed along with data and algorithm abstraction using object-oriented design and abstract data types. Detailed procedures are developed for analyzing the time and space complexities of general algorithms as well as an introduction to NP Completeness. Specific data structures discussed include generalized lists, trees, graphs, B-trees, and AVL-trees along with indexing, hashing, sorting, searching and recursive algorithms on specific structures. Well-founded algorithm design techniques like divide-and-conquer, local searching, and global searching are also introduced. Course projects emphasize the analysis, reuse, and extension of existing designs and implementations. Prerequisites: CSCE 486 (CSCE 083 is highly recommended). Fall and Winter Quarters
4 credit hours

CSCE 593 - INTRODUCTION TO SOFTWARE ENGINEERING: This course is concerned with the development of large scale software programs. Techniques in requirements analysis, design, implementation, testing, and maintenance are presented, along with discussion of the software development process. Several methodologies are discussed, including structured analysis (SA), object-oriented (OO)development, the Unified Modeling Language (UML), and the use of formal methods. Emphasis is on object-oriented modeling using a subset of the UML. Hands-on experience is provided through individual homework problems and a group project. Prerequisites: None. Fall Quarter
4 credit hours

CSCE 623 - Artificial Intelligence Systems Design: This course covers a selection of current state-of-the-art areas in artificial intelligence and intelligent systems design. In particular, emphasis is placed on the detailed development of complete systems. Areas include planning and scheduling, reasoning under uncertainty, vision, expert systems, natural language processing, machine learning, autonomous agents and distributed intelligence. Prerequisites: CSCE 523. 4 credit hours

CSCE 625 - Information Systems Security, Assurance and Analysis I: This course addresses the application of core computer science/engineering materials from the perspective of the computer-oriented information warrior. It synthesizes elements from computer networking and electromagnetic communications, operating systems security, and data security within a systems engineering framework. Topics to be addressed include: information coding and integrity; multi-level secure operating systems and networks; types of information attacks, detection strategies, countermeasures, hardening, damage assessment and control; issues on information security versus information assurance/timeliness; information system risk analysis and management; and IW modeling and simulation techniques. Prerequisites: CSCE525 and permission of instructor, (CSCE 654, CSCE 689, EENG 574 and CSCE 544 are highly recommended). Spring Quarter 5 credit hours

CSCE 631 - Machines, Languages and Logic: This course continues the theoretical development of computational machines, computational functions and formal languages and their interrelationships. Topics include finite automata, regular expressions, pushdown automata, Turing machines, Post Machines, recursively enumerable sets, recursive sets, recursive functions, decidability and Godel numbering. Associated algorithms on these computational models can be proven correct by developing a proof system using predicate calculus. Topics here include first and second order predicate calculus, resolution and unification. Using these foundations, designs are discussed from a computation viewpoint with emphasis on general computer software and hardware architectures. Prerequisites: CSCE 531, CSCE 532 and CSCE 586. Winter Quarter 4 credit hours

CSCE 646 - DBMS Structures and Implementation Issues: This course presents algorithms for enhanced relational DBMS operations including parallel and distributed query processing. A significant portion of the course is dedicated to trends in post-relational DBMS ranging from the extended relational model to the persistent object model for data representation. This course examines design and implementation issues surrounding the addition of object-based interface to the relational model as well as the augmentation of object-oriented programming languages with persistence and concurrency control. Finally, historical, current and emerging standards in both the relational and object-oriented DBMS are examined. Prerequisites: CSCE 546. Corequisite: CSCE 594. Spring Quarter 4 credit hours

CSCE 647 - Queuing in Computer Systems: This course emphases the theoretical understanding of queuing theory and its application to practical modeling of large and small-scale Air Force information processing networks. Monte Carlo simulation of queues is discussed. Stochastic modeling of computer networks employing Poisson arrival and service distributions using Markov processes is covered. Supporting simulation languages are presented. Steady-state or network balance equations are also developed as alternatives. Various types

of queues and associated scheduling algorithms are discussed. Using these models, computer performance is analyzed in terms of service times, throughput, routing algorithms and scheduling algorithms. Prerequisites: STAT 586 or STAT 601.
4 credit hours

CSCE 650 - SPECIAL TOPICS IN DIGITAL SYSTEMS: This course is based on the development and application of digital systems to current Air Force problems. The course focuses on one or more specific systems. The course emphasizes system architecture including both hardware and software, distributed intelligence, data structures simulation, information systems management, and other interdisciplinary topics. Prerequisites: None.
1-4 credit hours

CSCE 654 - COMPUTER COMMUNICATION NETWORKS: This course provides an introduction to the subject of the design and analysis of computer communication networks. Topics include network topology design, routing, flow control, random access techniques, local networks, and computer network protocols. Mathematical modeling and analysis based on basic queuing models and alternate design solutions are presented. Prerequisites: STAT 583 or STAT 586 or STAT 601. Spring Quarter
4 credit hours

CSCE 656 - PARALLEL AND DISTRIBUTED PROCESSING ALGORITHMS: This course develops an understanding of classical results for parallel design and analysis of algorithms. It provides practical insights into efficient and effective implementation on contemporary parallel computational machines. Topics discussed include process communications, process synchronization, task scheduling, parallel algorithm decomposition, real-time considerations and parallel programming environments. Application areas emphasized include sorting, searching, vector/matrix operations, graph algorithms, simulation, differential equations, logic programming and knowledge-based systems. A variety of programming assignments on parallel computers are required using a selected concurrent language. Prerequisites: CSCE 586. Spring Quarter
4 credit hours

CSCE 657 - SCIENTIFIC VISUALIZATION IN HIGH PERFORMANCE COMPUTING: The purpose of the course is to provide insight in the selection of appropriate scientific visualization techniques used in high performance computing HPC. Visualization techniques are applied to problems in physics, chemistry, biology, mathematics, computational fluid dynamics, computational electromagnetics, digital image processing and other models used in high performance parallel and distributed computing. Various techniques of data formatting, interrogation, and presentation, human factors, video tape, sound, 3D, etc., are studied. Such methods are analyzed in concert with commercial software visualization packages/languages. Example applications are studied on workstations and on the World Wide Web. As an integral element of the course, students will generate data on high performance computer platforms and then design and evaluate specific visualization techniques. Prerequisites: CSCE 656. Winter Quarter
4 credit hours

CSCE 663 - COMPILER THEORY AND IMPLEMENTATION: This course covers the theoretical foundation of formal languages and compiler theory including finite state automata, grammars, and lexical analysis. Laboratory exercises will include development of language parsers and familiarization with tools such as LEX and YACC. Prerequisites: CSCE 486, CSCE 532.
4 credit hours

CSCE 683 - ADVANCED DISTRIBUTED SIMULATION: This course introduces the important concepts and current technologies for advanced distributed simulation. The architecture, protocols, and concepts of the High-Level Architecture for distributed simulation are examined in detail. In addition, this course investigates important software, hardware, and networking issues affecting distributed simulation environments. Lab work reinforces classroom instruction by permitting students to develop an actual HLA simulation. Prerequisites: None.
4 credit hours

CSCE 684 - INFORMATION VISUALIZATION: The purpose of this course is to teach the student how to use computer graphics techniques, i.e., color, space, animation, highlighting, layout, etc., to convey the meaning of their data. Supporting the topics on graphics design are lectures on computer graphics fundamentals, user interface design, and graphic support languages and hardware. Classroom lectures are reinforced by selected laboratory projects in user interface or information display design. Prerequisites: None. Winter Quarter
4 credit hours

CSCE 686 - ADVANCED ALGORITHM DESIGN: Note: For those with the Computer Science major, this course must be taken before the thesis quarter. This course provides a theoretical and practical foundation for understanding and analyzing the design, complexity and correctness of algorithms (control structure) along with data structure and implementation considerations. The emphasis on computational models relating to NP complete problems is extended. The use of search algorithms (tree/graph, linear programming, dynamic programming, probabilistic, etc.) to solve NP complete problems is related to the selection of various problem-solving strategies including the incorporation of heuristics. Formal properties of the various approaches are studied using graph theory and computational models. Additional focus on logic programming, knowledge representation and automated reasoning in concert with the above topics provide a foundation in computational theory. In particular, applications in artificial intelligence, knowledge-based systems, software engineering, data base management, signal processing, VLSI, and computer architecture are related through algorithm modeling and current literature. Prerequisites: CSCE 586, CSCE 431. Spring Quarter
4 credit hours

CSCE 687 - ADVANCED MICROPROCESSOR DESIGN LABORATORY: This is a project-oriented course which emphasizes the application of microprocessor systems to practical problems. Students, working in small groups, will be expected to design and implement a microprocessor-based project. This includes both hardware and software design, implementation and testing. A final report is required. Prerequisites: CSCE 487. Summer Quarter 3 credit hours

CSCE 689 - DISTRIBUTED SOFTWARE SYSTEMS: The objective of this course is to rigorously extend the fundamentals of computer operating systems into more advanced features. Topics include distributed operating systems, distributed file systems, distributed scheduling, fault tolerance, and multiprocessor operating systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties as well as case study analysis of existing and proposed advanced operating systems. Prerequisites: CSCE 431, CSCE 489 and CSCE 492. Summer Quarter 4 credit hours

CSCE 692 - DESIGN PRINCIPLES OF COMPUTER ARCHITECTURE: The objective of this course is for the student to understand and be able to apply the fundamental principles of computer architecture design. An emphasis is placed upon the use of quantitative metrics to evaluate cost/performance tradeoffs and upon the use of actual performance data to evaluate design alternatives. Specific topics include instruction set architecture design, pipelining, super scalar/VLIW processors, out-of-order execution, compiler optimization, memory optimization, memory system design, and input/output systems. Prerequisites: CSCE 489 and CSCE 492. Winter Quarter 4 credit hours

CSCE 693 - SOFTWARE EVOLUTION: This course explores the management and modification of large-scale software systems as they evolve over time. Relevant techniques and processes from CSCE 593 are discussed as they apply to software evolution and maintenance. Additional concepts such as reverse-engineering and configuration management are also investigated. Course concepts are reinforced through homework exercises and projects. Prerequisites: CSCE 593 Introduction to Software Engineering. 4 credit hours

CSCE 694 - ADVANCED SOFTWARE ENGINEERING: This course is concerned advanced topics in the development of large scale software systems. Emphasis is on formal-based object-oriented modeling and the Unified Modeling Language (UML), the use of software architectures in software system design, and software product metrics, including measurement theory. Hands-on experience is provided through individual homework problems and a group project. Prerequisites: CSCE 431 (or equivalent), CSCE 486 (or equivalent), CSCE 593. Spring Quarter 4 credit hours

CSCE 723 - ADVANCED TOPICS IN ARTIFICIAL INTELLIGENCE: This course treats topics selected to prepare students for research in artificial intelligence and for application of artificial intelligence in the solution of commercial and military problems. Typical topics are knowledge-engineering, uncertainty, learning, constraint-satisfaction, neural networks, knowledge acquisition, model and case-based reasoning, nonmonotonic reasoning, blackboard systems, and theorem proving. Prerequisites: CSCE 623. 4 credit hours

CSCE 725 - INFORMATION SYSTEM SECURITY, ASSURANCE AND ANALYSIS II: This course is a continuation of CSCE 625, placing increased emphasis on offensive information warfare techniques (information attack, offensive counterinformation). Students will apply their IW knowledge in group design and analysis projects, explore several IW case studies, propose solutions and analyze their proposals. Prerequisites: CSCE 625. Summer Quarter 4 credit hours

CSCE 746 - ADVANCED TOPICS IN DATABASE SYSTEMS: This course covers advanced current topics in the area of object-oriented and distributed multi-database systems (MDBS). Specific topics are oriented toward Air Force interest, local research emphasis, student interest, and trends in the object-oriented and multi-database technologies. Illustrative projects and or point papers give the student opportunities to explore some areas of the appropriate fields in enough depth to engender an appreciation and working knowledge for the complexity of the domain. Prerequisites: CSCE 646. Summer Quarter 4 credit hours

CSCE 754 - ADVANCED TOPICS IN COMPUTER NETWORKS: The objective of this course is to extend the fundamentals of computer communication systems into more advanced features. Topics include Asynchronous Transfer Mode (ATM) technologies, protocols for self-healing, data security, data compression techniques, and recent advances in the Internet Protocol (IP). Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required systems properties. These types of analyses are reinforced through simulation projects using the tool Designer. Prerequisites: CSCE 654 and STAT 583.
Summer Quarter 4 credit hours

CSCE 756 - LOGIC PROGRAMMING: This course treats the theory of logic-based programming and its realization in the Prolog language. Topics include representation and reasoning in Horn-clause logic, the computational model of logic programs, pure Prolog and its practical extensions, advanced programming techniques, and applications. Prerequisites: CSCE 523. 4 credit hours

CSCE 783 - ADVANCED TOPICS IN GRAPHICS AND VISUALIZATION: This course examines in detail, selected topics from current research areas in computer graphics and information visualization. Characteristic topics include virtual environments, human-computer interaction, visualization techniques and applications and modeling of synthetic environments. This is a project oriented course with topics and projects varying from year to year. Prerequisites: CSCE 684 or CSCE 582. 4 credit hours

CSCE 786 - TEMPORAL LOGIC AND CONCURRENT PROCESSES: This course continues the theoretical development of the relationships between predicate logic and the construction of temporal logic with application to concurrent computational models. Structuring such systems as algebraic models or process algebras is integrated with associated properties of behavioral equivalence, fairness, safety, and liveness. The eventual focus is on proving concurrent algorithm designs correct using temporal logic and predicate logic within a concurrent computational model. Such a temporal proof system includes axioms and inference rules and operator classification. Using this foundation, general temporal reasoning applications are discussed from a design, implementational and computational viewpoint with application to process verification and behavior analysis. Use of the Edinburgh concurrent workbench (CWB) is employed for CCS model analysis. Use of other environments may also be integrated. Prerequisites: CSCE 631.
4 credit hours

CSCE 788 - ADVANCED TOPICS IN COMPUTER ARCHITECTURE: The objective of this course is for each student to be able to apply the concepts of advanced computer architecture to the design and application of computers. A critique of current architectures and considerations for improved architectures are covered. Prerequisites: CSCE 692 or Permission of Instructor.
4 credit hours

CSCE 790 - ADVANCED PARALLEL AND DISTRIBUTED COMPUTATION: The purpose of this course is to continue the development of insight into parallel and distributed computation through the use of case studies. Current literature is stressed to support current student research. The students explore advanced topics in parallel and distributed computation related to their individual research. Application examples include computational fluid dynamics, computational electromagnetics matrix operations, ODE and PDE solutions, parallel AI/expert systems, computational graphics, simulation, searching, and other topics of military interest. The exploration of advanced topics is conducted in a seminar fashion in order to provide integration of interdisciplinary concepts. Using case studies of current results for parallel and distributed algorithm design and analysis, practical insights are provided for efficient and effective implementation on contemporary parallel computational machines. Prerequisites: CSCE 656. Summer Quarter 4 credit hours

CSCE 792 - PARALLEL COMPUTER ARCHITECTURE: This course explores ways in which greater computing power can be achieved by exploiting parallelism. Architectures for exploiting parallelism at different granularities are examined. Superscalar and VLIW (very long instruction word) systems are examples of architectures that exploit instruction-level parallelism. For exploiting more coarse-grain parallelism (e.g., loop-level or procedure-level), architectures employing multiple processors are examined. Both shared memory and distributed memory architectures are discussed. Advanced topics such as SIMD architectures, dataflow architectures, and multi-threading are also covered. Prerequisites: CSCE 692. Additionally, CSCE 656 is highly recommended.
4 credit hours

CSCE 793 - ADVANCED TOPICS IN SOFTWARE ENGINEERING: This course covers advanced current topics in the area of software engineering. Specific topics are oriented toward Air Force interest, local research needs, student interest and trends in software engineering research and practice. Prerequisites: CSCE 694 and CSCE 531. Summer Quarter 4 credit hours

CSCE 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: CSCE 698 and Permission of Instructor.
1-12 credit hours

CSCE 850 - ADVANCED DIGITAL SYSTEMS: This is an advanced course based upon current Air Force problems in the area of digital systems design, analysis and synthesis. The course focuses on one or more specific systems. The course emphasizes system architecture including both hardware and software, distributed intelligence, data structures, simulation, information systems management, and other interdisciplinary topics. Prerequisites: CSCE 489, CSCE 492, CSCE 594.
4 credit hours

CSCE 886 - EVOLUTIONARY ALGORITHMS: This course provides a theoretical and practical foundation for continuing the understanding and analysis associated with the design, complexity and correctness of evolutionary algorithms. Evolutionary algorithms using genetic algorithms, evolutionary strategies and classifiers are discussed as probabilistic search algorithms. Evolutionary data representation and fitness function selection along with associated operators and population dynamics are thoroughly developed. Formal properties of various evolutionary approaches are addressed using graph theory, predicate calculus and computational models. Evolutionary algorithm implementations are associated with proper data and control structure selection, implementation and visualization considerations for serial, parallel, and distributed computation. Application problems in artificial intelligence, knowledge-based systems, software engineering, database management, signal processing, VLSI, simulation, scheduling, planning and computer architecture design are related through similarity of domain structures. Prerequisites: CSCE 686. Fall Quarter
4 credit hours

CSCE 893 - KNOWLEDGE-BASED SOFTWARE ENGINEERING: This course investigates the integration of software engineering with knowledge representation and manipulation techniques from artificial intelligence. The first part of the course evaluates different approaches for applying knowledge-

based technology to software engineering tasks such as program understanding, reengineering, and synthesis. The second part of the course emphasizes the application of object-based and algebraic techniques for knowledge representation as well as the role of theorem proving. An integral step in this part is the application of the techniques to the development of domain theories for an application domain and the representation of well-founded software engineering knowledge in the areas of software architectures, algorithms, and data structures. Prerequisites: Permission of instructor (Desired: Strong background in AI and Software Engineering).
4 credit hours

CSCE 894 - SOFTWARE SYNTHESIS: The objective of this course is to perform and in-depth investigation of software synthesis, and it directly builds on the concepts covered in CSCE 793. Software synthesis techniques based on algebraic specifications and category theory operations are examined and applied to example problems from a variety of domains. Major topic areas in the course are: how problem structure guides the synthesis process, proof obligations associated with the category theory operations, and how optimizations are applied. Prerequisites: CSCE 793.
4 credit hours

CSCE 999 - DISSERTATION RESEARCH: Prerequisites: None.
1-16 credit hours (var.)

ELECTRICAL ENGINEERING

EENG 510 – LINEAR SYSTEMS: The objective of this course is to develop tools for the analysis and simulation of linear dynamic systems. Emphasis is placed on state space analysis for estimation and control theory applications. Topics covered include: linearization of a nonlinear system, derivation of linear time-invariant and time varying state equations, and the continuous time solution; relations between the state equations and the system transfer function; eigenvalue/eigen-vector and singular value analysis of the state equations; transformations to canonical forms; and controllability and observability properties. Prerequisites: None. Fall Quarter 4 credit hours

EENG 515 – LINEAR SYSTEMS, FOURIER TRANSFORMS, AND OPTICS: This course provides an introduction to the analysis and synthesis of linear systems with emphasis on applications for electro-optic systems, communications and pattern recognition systems. As a result, functions of space and time are treated throughout. Topics to be covered include: mathematical representations of physical quantities, Fourier analysis and physical systems, linear filtering and modulation, convolution and correlation, propagation and diffraction of optical wavefields, image-forming systems as well as elementary geometric optics and simple multi-resolution analysis. Prerequisites: None. 4 credit hours

EENG 524 – INTRODUCTION TO ELECTROMAGNETIC WAVES: This course focuses on the study of Maxwell's equations in the time and frequency domains. Faraday's and Ampere's laws are used as the catalyst to describe the coupling of time-varying electric and magnetic fields. The dynamics and properties of electromagnetic wave propagation and polarization is explored for a variety of both lossless and lossy media. This naturally leads to an extensive study of transmission lines using both analytic (circuit models) and graphical (Smith Chart) methods. Then field boundary conditions and the interactions at media interfaces are introduced in order to study the phenomena of reflection, refraction, and diffraction. Finally a variety of waveguides including optical fibers are studied to introduce wave theoretic models for transmission lines or guided waves. Prerequisites: Permission of Instructor. Fall Quarter
4 credit hours

EENG 527 – INTRODUCTION TO FOURIER OPTICS: This course presents a systems approach to the analysis and design of both coherent and incoherent optical systems, with emphasis on applications. Topics include: methods of analysis of two dimensional linear systems, scalar diffraction theory, Fourier transform properties of lenses, frequency analysis of imaging systems, spatial filtering concepts with selected applications, and holography. Important applications of Fourier optics to Air Force systems are stressed throughout the course. Prerequisites: Permission of Instructor.
4 credit hours

EENG 529 – REMOTE SURVEILLANCE: This course presents the models and methods required for and used in remote surveillance systems, such as satellite-based systems that acquire and process ground imagery. Topics covered include the nature of remote sensing, optical radiation models, sensor models, data models, spectral transforms, spatial transforms, correction and calibration, image registration and fusion, and thematic classification. Applications to Air Force systems are emphasized throughout the course. Prerequisites: Permission of Instructor.
Summer Quarter 4 credit hours

EENG 530 – ANALOG COMMUNICATION THEORY: Analysis of analog communications systems in the presence of noise. Topics include: Statistical models of modulated carrier signals; antenna parameters; channel models; noise sources and system noise calculations; link budget calculations; nonlinear detectors; performance analysis of AM, FM, PM, and FDM receivers; introduction to digital communication systems, including analysis of quantization error and matched filter receiver for baseband binary signals; system design considerations and examples. Prerequisites: None.
Fall Quarter 4 credit hours

EENG 533 – NAVIGATION USING THE GLOBAL POSITIONING SYSTEM: This course provides a theoretical and practical foundation for understanding the Global Positioning System (GPS). Emphasis is on the use of GPS for determining navigational information such as user position and velocity relative to the local navigation frame of reference (latitude, longitude, altitude, and their time derivatives). Topics include basic properties, navigation solution theory, satellite orbits and positioning, signal structure, code generation, code correlation, receiver design, ranging errors, geometrical errors, differential GPS, relative GPS, and carrier-phase GPS. An important aspect of this course is hands-on experience using actual GPS receivers such as the XR5 from NAVSIMM and the navcard by Rockwell. These receivers connect to common PCs such as the 486-33 and are ideally suited for academia because all ephemeris data and raw measurements are attainable. Also, an important part of this course is the review of numerous contemporary GPS articles such as those found in the Institute of Navigation's (ION's) Journal on Navigation. By the conclusion of this course, the student will be able to extract ephemeris and correctional parameters from the carrier loop, collect actual pseudo-range and pseudo-range rate from the code loop, compute satellite positions, write at least squares algorithm to determine user position and velocity, write algorithms to perform differencing (emphasis on differential and relative GPS), and write an algorithm to exploit carrier-phase information to compute the navigational parameters. In addition to learning how to use a GPS receiver, the student will become well-versed in the theoretical aspects of GPS, and so will be able to read and criticize current GPS research. Prerequisites: None. Spring Quarter 4 credit hours

EENG 534 – Fundamentals of Aerospace Instruments and Navigation Systems: Basic reference frames are defined and coordinate transformations are derived. The applicable laws of mechanics are used along with basic control system theory to analyze the kinematic and dynamic behavior of inertial sensors used in attitude and tracking systems. Vector and matrix notation are used throughout. Topics covered are the earth model, two-degree-of-freedom and single-degree-of-freedom tuned and floated mechanical gyroscopes, laser gyroscopes, linear accelerometers, inertial platforms, and unconventional inertial devices. Non-inertial instrument topics include radar, radio aids to navigation, optical trackers, and satellite navigation. The emphasis is on developing practical mathematical models useful to the guidance and control engineer. Examples are taken from current and planned Air Force systems. Prerequisites: EENG 562, MECH 423. Winter Quarter 4 credit hours

EENG 535 – Radar Systems Analysis: This course covers all aspects of a radar from a systems point of view beginning with the definition and concluding with signal processing. After explaining the functions and characteristics of the transmitter, antenna, receiver, displays and the principles of microwave propagation and interaction with media, the Radar Range Equation is derived. Techniques of measurement and tracking of range, velocity, azimuth and bearing of a moving target are discussed. Recently introduced radars, such as the Over-the-Horizon, Synthetic Aperture, Terrain Following and Terrain Avoidance are briefly discussed. Prerequisites: EENG 530, STAT 586. Winter Quarter 4 credit hours

EENG 540 – Robotic Fundamentals: The objective of this course is to introduce the student to the fundamental principles of robotics. Principles of robotic manipulation: design, trajectory planning, sensing, and computer systems are surveyed. The study of kinematics and motion and force control is presented in detail. Current applications are also discussed. Throughout the course, the emphasis is on the design and analysis of Air Force systems. Lectures are reinforced with a series of laboratory group projects that include experimental evaluations on a PUMA-560. Prerequisites: EENG 562 or SENG 565. 4 credit hours

EENG 548 – Human Factors Engineering: Many complex control and data processing systems include human operators to perform data evaluation, processing and control functions. This human element is poorly understood and frequently badly matched to the system requirements. This course will develop mathematical descriptions of human sensory data processing channels and muscular control capabilities to the extent that they are presently understood. The typical feedback control and data processing systems depending on human performance will be analyzed. Prerequisites: None. Winter Quarter 4 credit hours

EENG 562 – FEEDBACK SYSTEMS: This course covers the fundamental characteristics and design of linear feedback control systems. Root locus and frequency response methods of design and developed. A variety of electrical, mechanical, thermal and hydraulic systems are considered, and they are represented by block, signal flow, and simulation diagrams. System stability, performance and use of cascade compensation to improve performance are included. The state equation modeling of systems includes the use of physical variables and the transformation to phase variable and diagonal or normal form. Simulation and signal flow diagrams are used to represent the state equation formulation. Use of CAD design programs are emphasized. Prerequisites: EENG 510. Fall Quarter 5 credit hours

EENG 571 – SATELLITE COMMUNICATIONS: The objective of this course is to provide a comprehensive introduction to modern communication principles with particular emphasis on applications to satellite and space communication systems. Topics include: modulation, signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware, earth station hardware, and link analysis. Prerequisites: None. Winter Quarter 4 credit hours

EENG 574 – COMMAND, CONTROL, COMM, AND COMPUTER C4 WARFARE: Examines the structure and dynamics of C4 systems. In the context of this course, command and control is treated as a problem in generating, transferring, and managing information. The essence of C4 warfare is making effective decisions while degrading the enemy's ability to do the same. All C4 warfare physical systems use technologies derived from the fundamentals of communication theory. Thus, the course presents the main components of a generalized communication system in sufficient detail so the student can understand technical discussions of actual C4 warfare systems and architectures. Topics include fundamental communication engineering theories and techniques; satellite, terrestrial, ionospheric, and optical communication systems; radar, infrared, electro-optical, and electronic combat systems; Army, Air Force, Navy, Marine, and Joint tactical and strategic communication systems and their performance in recent conflicts. A thoughtful term paper and class presentation on a specific C4 warfare system is an integral part of the course and the primary vehicle for building our knowledge base of DOD C4 warfare systems. Prerequisites: (Enrollment limited to US citizens. Not open to GE students for credit).
4 credit hours

EENG 576 – MICROWAVE CIRCUITS: This course presents material on the application of electromagnetic theory to microwave propagation in wave guiding structures. Topics include waveguides, microwave network analysis, impedance matching and tuning, microwave resonators, power dividers, directional couplers, and hybrids. Prerequisites: EENG 524.
4 credit hours

EENG 580 – INTRODUCTION TO SIGNAL PROCESSING: This course presents an introduction to signal processing. Topics include I/O descriptions of discrete-time systems, Z-transforms, Discrete Fourier Transforms (DFT) and Fast Fourier Transforms (FFT), Finite Impulse Response (FIR) filter design, and Infinite Impulse Response (IIR) filter design. Prerequisites: MATH 521. Fall Quarter 4 credit hours

EENG 596 – INTEGRATED CIRCUIT TECHNOLOGY: This course presents the theoretical and physical principles involved in realizing practical devices from silicon and gallium arsenide. Implementation and fabrication of integrated circuits are stressed. The concepts of crystal structure, energy bands, carrier concentration, and carrier transport phenomena are explained. Discusses the basic fabrication processes relevant to integrated circuits. The following topics are developed: crystal growth, epitaxy, oxidation, dielectric and metallic film deposition, diffusion and ion implantation, lithography, and etching. Prerequisites: Permission of Instructor. Fall Quarter 4 credit hours

EENG 599 – SPECIAL STUDY: Directed study at a beginning graduate level on a special topic which is not normally covered in a regularly scheduled course or as part of thesis research. Prerequisites: Permission of Instructor. 1-4 credit hours

EENG 617 – MATHEMATICAL MODELLING OF THE CENTRAL NERVOUS SYSTEM: This course develops models of the information processing functions of the central nervous system. The ability of animal nervous systems to process visual and auditory information is unsurpassed; it should be possible to adapt some of their techniques to solve current operational problems such as automatic scene analysis to guide smart munitions or automatic speech recognition to enable natural human-machine data transfer. Current knowledge of these natural functions will be discussed along with actual and potential realizations of such functions in hardware. Prerequisites: None. 4 credit hours

EENG 618 – SENSORY COMMUNICATIONS: Primary emphasis concerns behavior of animal sensory mechanisms. Chemical and mechanical structures and electrical behavior of typical animal sensors are described with particular consideration of fundamental limitations of human sensory systems. Both subjective and objective aspects of sensory mechanisms are described. These principles are applied in the design of Air Force information processing and display systems. Prerequisites: EENG 617. 4 credit hours

EENG 619 – ADVANCED TOPICS IN MATHEMATICAL MODELLING OF THE CENTRAL NERVOUS SYSTEM: This course is an advanced course based on current literature and technical reports. Applications of current mathematical modelling techniques to biological information processing are studied. Prerequisites: EENG 617 and EENG 618. 4 credit hours

EENG 620 – INTRODUCTION TO STATISTICAL PATTERN RECOGNITION: A study of the theory and design of automatic machine recognition of complex patterns. Such machines are applied to Air Force problems in areas like target detection and identification, automatic navigation, multispectral data analysis, seismic discrimination and speech recognition. Specific topics include: Bayesian analysis, discriminant functions, parametric and nonparametric classifiers, learning algorithms (supervised, unsupervised, deterministic, and statistical), relationships between geometrical and statistical formulations, and neural networks. Prerequisites: STAT 586. Winter Quarter 4 credit hours

EENG 621– THEORY AND APPLICATIONS OF PATTERN RECOGNITION: This course will examine pattern recognition techniques for one and two-dimensional signals. Speech processing will be the major application for one-dimensional signal processing. Image processing will be the primary application for two-dimensional signal processing. Specific topics for speech processing include linear prediction, vector quantization, hidden Markov models, dynamic time warping and applications such as speech recognition, speaker identification, and speech coding. Image processing topics included are segmentation, feature extraction, and compression. Prerequisites: EENG 620. Spring Quarter 4 credit hours

EENG 625 – ANTENNAS I: The basis of this course is the electromagnetic field produced by known source distributions, and fundamental antenna concepts such as gain, reciprocity, equivalence, duality, polarization and radiation pattern. The general behavior of dipoles, loops, and wire antennas is developed. An introduction to arrays of identical antennas is presented. Aperture antennas, including horns and reflectors, and their feed structures are studied. Prerequisites: EENG 524. Winter Quarter 4 credit hours

EENG 626 – MICROWAVE LABORATORY: This is a laboratory course designed to illustrate transmission line and wave guiding concepts. Microwave devices are studied via their scattering parameters. Measurement of power, frequency, and impedance at microwave frequencies is addressed. Laboratory measurements include use of the slotted waveguide, spectrum analyzer, and the network analyzer. Prerequisites: EENG 524. Winter Quarter 1 credit hour

EENG 627 – RCS ANALYSIS, MEASUREMENT, AND REDUCTION: Radar Cross Section (RCS) characteristics of simple and complex shapes. Methods of RCS reduction. Radar absorbing materials (RAM) and radar absorbing structures (RAS). Design requirements and performance of RCS measurement systems. Frequency and time domain analysis of RCS data. Statistical processing of RCS data. Includes extensive laboratory RCS measurements. Prerequisites: EENG 626, EENG 630. Summer Quarter 4 credit hours

EENG 628 – ADVANCED ELECTROMAGNETIC WAVES: The focus of this course is methods for analyzing the propagation and scattering of electromagnetic waves. It begins with a review of plane wave propagation in unbound media and the reflection and transmission of waves at planar interfaces. The uniqueness of solutions to Maxwell's equations and construction of modal solutions to the homogenous vector wave equation are then addressed. Solutions to the wave equation in rectangular, cylindrical, and spherical coordinates are examined. Numerous boundary value problems are considered including rectangular and circular waveguides and cavities, the spherical cavity, and scattering by cylinders and spheres. The course concludes with a look at constructing Green's functions for boundary value problems involving the inhomogeneous scalar wave equation. Prerequisites: EENG 524, MATH 504. Winter Quarter 4 credit hours

EENG 629 – ELECTRONIC COMBAT: This is a graduate level course with an in-depth analysis, synthesis, and design of electronic warfare systems. Radar/Electronic Countermeasure interactions. Statistical model of chaff and effects on moving target indication radar (MTI). Response of conventional receivers to Direct Noise Amplification, AM by Noise, and FM by Noise. Scan rate modulation and inverse gain repeaters. Detailed analysis of monopulse countermeasures, such as cross-eye, cross-pol, terrain bounce, and jamming from multiple platforms. Side-lobe canceler, adaptive nulling, and Dicke Fix receivers. Intercept problems and different kinds of intercept receivers. Introduction to signal sorting and de-interleaving. Prerequisites: EENG 535. Spring Quarter 4 credit hours

EENG 630 – APPLICATIONS OF ELECTROMAGNETIC THEORY: Analytical and numerical techniques to solve electromagnetic radiation and scattering problems. Both low and high frequency methods are discussed. The principal subjects are the geometrical theory of diffraction, physical optics, and the method of moments. The strengths and limitations of these methods as applied to complex practical problems are discussed. A substantial amount of computer programming of the methods is involved. Prerequisites: EENG 625 or EENG 628. Spring Quarter 5 credit hours

EENG 631 – ADVANCED ANTENNAS: Transform methods for analyzing antennas are explored. Broadband and frequency independent antennas are discussed, such as the binconical, bow-tie, traveling wave, spiral, and log-periodic antennas. In addition to the frequency domain analysis, time domain techniques are explored, including solving Maxwell's Equations in the differential time domain form. Prerequisites: EENG 625. Spring Quarter 4 credit hours

EENG 633 – ADVANCED GPS THEORY AND APPLICATIONS: Advanced topics in GPS are presented, building on the foundation laid in EENG 533. A precise description of each of the GPS observables is presented, with an emphasis on differential positioning. Real world error sources are analyzed, including satellite position, ionospheric, troposheric, multipath, and receiver measurement noise errors. A major portion of the course describes receiver design and signal processing methods used by GPS receivers. Current literature and laboratory projects provide enhanced insights into GPS receivers and systems. Prerequisites: EENG 533. Summer Quarter 4 credit hours

EENG 635 – INERTIAL NAVIGATION SUBSYSTEMS: The inertial navigation system (INS) concept is defined and analyzed in the context of space stabilized, local level and strapdown configurations. Perturbation techniques are applied in the derivation of unified INS error models. The earth's gravitational field model is developed. Advantages and disadvantages of various configurations are presented within the context of the INS error dynamics. Methods of system alignment are examined. System response to inertial instrument errors, initial misalignments, and other sources are studied in frequency and time domains. System analysis tools, such as MATLAB are used throughout. Prerequisites: EENG 534. Spring Quarter 4 credit hours

EENG 636 – MICROSENSORS AND ACTUATORS: Microelectromechanical systems (MEMS) are rapidly emerging as the new revolution in miniaturization for microsensors and actuators. Complete integrated systems, composed of digital, analog and mechanical devices, are now being fabricated on a single integrated circuit chip. The motivation for this new technology is the reduced cost of fabrication, reduced size and improved performance. This is a new frontier for microelectronics, specifically in the areas of device modeling and fabrication. The objective of the course is to address the issues of MEMS device modeling and fabrication. The design and fabrication of sensors and actuators will be emphasized, due to the significance of their future applications in optics, optical computing, memory devices, medical instruments, inertial navigation components and microrobotics. Prerequisites: Permission required. Winter Quarter 4 credit hours

EENG 640 – AUTOMATIC FLIGHT CONTROL I: Introduction to aircraft flight control systems. Derivation of transfer functions for aircraft and missiles, along with servo actuators and sensors. Use of conventional and modern control theory to analyze and design longitudinal and lateral-directional stability augmentation systems and control augmentation systems. Study of flight control systems and autopilot design for various tasks including turn coordination and automatic landing, stabilization of inertially cross coupled aircraft, adaptive control systems for aircraft and missiles, and effects of sensor noise are studied. Prerequisites: EENG 510, EENG 562, EENG 660, and MECH 529. Spring Quarter
4 credit hours

EENG 641 – AUTOMATIC FLIGHT CONTROL II: A study of state-of-the-art flight control system design with examples taken from current Air Force systems. Digital, analog, and hybrid flight control systems are examined. Laboratory practices associated with the testing and analysis of flight control system equipment and designs. Experiments include the design, dynamic simulation and evaluation of an aircraft automatic flight control system on a hybrid computer. Control surface limits and other nonlinearities are included in the simulation. Prerequisites: EENG 640. Summer Quarter
3 credit hours

EENG 643 – AEROSPACE VEHICLE TESTING AND INSTRUMENTATION: This course is intended for students interested in aircraft and integrated systems flight testing. The objectives are to present the three classical areas of flight testing - performance, stability and control, and systems test - and the three emerging flight test areas of integrated avionics, integrated systems, and command and control. The course includes modern instrumentation and data processing techniques, including "intelligent" test stations and the methods of engineering analysis for man-in-the-loop testing. Topics include inertial instrumentation, system identification techniques for trajectories, stability derivatives, pilot models, and vehicle component performance analysis. Prerequisites: MECH 423, MECH 529, EENG 562, and EENG 640.
4 credit hours

EENG 653 – INTRODUCTION TO VLSI DESIGN: The purpose of this course is to equip the student with the fundamentals of VLSI design, including design methodologies, circuit modeling and analysis, mask layout, simulation and design verification. The focus is on each element of the design cycle. At each stage in the cycle both the theoretical concepts and the appropriate CAD tools are presented together. Practical experience is gained through the design of circuits of relatively low complexity. The VHSIC Hardware Description Language is used throughout to specify and document circuit designs. Prerequisites: CSCE 488 and a background in VHDL. Fall Quarter
4 credit hours

EENG 655 – DISCRETE-DATA CONTROL SYSTEMS: The study of control systems which contain discrete signals, including systems which contain digital computers. Topics include the sampling process, difference equations, the Z-transform, system stability, and the determination of output performance. The root-locus method of analysis is stressed. Compensation techniques are presented along with the Pade' and Tustin approximations. Design methods applicable to Air Force systems are included. The course includes the application of computer-aided design techniques. Prerequisites: EENG 562, EENG 510. Winter Quarter
4 credit hours

EENG 660 – FEEDBACK SYSTEMS II: A continuation of EENG 562. Improvement of SISO closed-loop system is achieved by using cascade and feedback compensation (root locus and frequency response methods). Principles of state feedback and tracking performance are applied to SISO systems. Eigenstructure assignment (eigenvalues and eigenvectors) and an introduction to quantitative feedback theory (QFT) are applied to MIMO control systems. Output feedback for MIMO systems is used for tracking systems. Nonlinear control properties, describing functions, and dual-input describing functions are studied for systems stability in tracking systems. Prerequisites: EENG 510 and EENG 562. 4 credit hours

EENG 662 – OPTIMAL FEEDBACK CONTROL: Control system representation by physical, phase, and canonical state variables; state-variable feedback control systems; stability and the state function of Liapunov; optimal control and the state function of Pontryagin; two-point boundary value problem; optimal synthesis of linear systems by solution of the linear quadratic regulator problem; performance modeling and methods of achieving desired closed-loop performance; output sensitivity minimization to parameter variation. Robustness issues in control system design are discussed. The course stresses applications to practical Air Force problems and the utilization of interactive computer-aided design techniques, e.g. the MATLAB or Matrix software. Prerequisites: EENG 510 or EENG 562. 4 credit hours

EENG 664 – DIGITAL CONTROL SYSTEMS: The objective of this course is to analyze the theoretical and structural relationships between control theory, digital signal processing and digital system design. Use of both the time and the frequency domains for systems design are emphasized. Scalar and vector matrix models are employed in the development of digital control methods (classical, modern). Analog-to-digital and digital-to-analog conversion techniques are studied as part of the general real-time control system model. Design trade-offs between system performance and the physical and economic constraints are considered. Appropriate constraints, such as timing requirements, memory size, costs, computer word length, and accuracy are considered. Real-time operating systems are discussed as related to real-time digital control systems. The course emphasizes the application of interactive computer-aided design packages. Prerequisites: EENG 655, MATH 580 or STAT 601 or STAT 586. 4 credit hours

EENG 665 – RANDOM SIGNAL AND SYSTEM ANALYSIS: An introduction to the theory of random signals as it applies to communications. The concepts developed include: random signals, moments, correlation functions, stationarity, ergodicity, power spectral density, joint processes and their cross-correlation random signals in linear systems, and specific types of random processes. Prerequisites: STAT 586. Winter Quarter 4 credit hours

EENG 666 – SIGNAL DETECTION AND ESTIMATION: A study of techniques for extracting information signals corrupted by noise. Maximum Likelihood, Neyman Pearson, Ideal Observed, Bayes, and Mini-Max decision criteria. Binary and multiple decisions under single and multiple observations. Detailed consideration of signals in Gaussian noise. Karhunen-Loeve expansion and detection of signals in colored noise. Composite hypothesis. Sequential and non-parametric decision theories. Maximum Likelihood, Least Squares, Minimum Variance, and

Bayes estimators. Efficient estimators and Cramer-Rao bounds. Introduction to Kalman Filter. Prerequisites: EENG 665. Summer Quarter 4 credit hours

EENG 668 – ADVANCED RADAR SYSTEMS ANALYSIS: The objective of this course is to provide an analytical foundation for the evaluation of radar receiver design. It applies the principles of detection, estimation, and modulation theory to the radar problem. Topics to be covered include: statistical target models that describe the fluctuations of the return signal, optimum receiver design and performance evaluation, and the radar ambiguity function as applied to signal design. Examples are drawn from Air Force radar systems. Prerequisites: EENG 535. Corequisites: EENG 666. Summer Quarter 4 credit hours

EENG 669 – DIGITAL COMMUNICATIONS I: The objective of this course is to present the significant considerations necessary for the design and analysis of digital communication systems. The course develops a mathematical representation of digital signals including signal space concepts. The use of source decoding for efficient descriptions of information sources is motivated. Channel coding concepts are developed and shown to improve communication system performance. Techniques of block and convolutional channel coding are summarized, hard and soft decision decoding is discussed, and system performance is analyzed. Prerequisites: STAT 586 and EENG 530. Winter Quarter 4 credit hours

EENG 670 – DIGITAL COMMUNICATIONS II: The objective of this course is to present the significant considerations necessary for the design and analysis of bandpass digital communication systems. This course examines coherent and noncoherent detection of digital bandpass signals in Gaussian noise and the corresponding error performance for binary and M-ary signaling. Modulation and coding trade-offs are discussed. Methods of synchronization at the carrier, symbol, and frame rates are examined. Multiplexing and multiple access networking techniques are also explored, and a brief introduction to spread spectrum systems is provided. Prerequisites: EENG 665 and EENG 669. Spring Quarter 4 credit hours

EENG 672 – STATISTICAL OPTICS: This course presents a systems approach to the analysis and design of electro-optic systems with emphasis on the stochastic nature of the optical fields. Topics include: the temporal and spatial coherence properties of light, propagation of coherence properties of light, effects of partial coherence on imaging systems, and imaging in the presence of randomly inhomogeneous media. The end of the course will emphasize applications such as speckle imaging, imaging using adaptive optics, and interferometric imaging. The course is designed to give students the ability to analyze and design optical systems which require the consideration of the non deterministic nature of the light itself as well as its interaction with the optical system. Prerequisites: EENG 527 and EENG 665. Spring Quarter 4 credit hours

EENG 673 – SPREAD SPECTRUM COMMUNICATIONS: This course examines the design and analysis of spread spectrum communications systems. The various forms of spread spectrum modulation, such as direct sequence, frequency hopping, time hopping, and hybrid forms, are discussed. Coding techniques for ranging and multiple access are also developed. Methods of synchronization at the carrier, chip, and data symbol rates are also examined. A major portion of the course is dedicated to applications of spread spectrum techniques, such as code division multiple access, Global Positioning Systems, low probability of intercept, and antijam communications. Prerequisites: EENG 670. Summer Quarter 4 credit hours

EENG 675 – SEMICONDUCTOR DEVICE TECHNOLOGY: This course is the focal point of the electronic devices sequence. The major types of semiconductor devices will be analyzed in terms of the physical effects which govern device operation. From this study, design equations, circuit models, and performance limitations are developed. After a review of quantum mechanics and pertinent conduction theory, the major device categories are presented. These topics include PN-junction diodes, bipolar and field-effect transistors, and metal-oxide-semiconductor devices. Prerequisites: PHYS 570. Winter Quarter
4 credit hours

EENG 676 – MICROWAVE ELECTRONIC DEVICES: The theory of operation and design models for semiconductor microwave devices are developed. Emphasis is placed on factors affecting selection and application of semiconductor devices in microwave systems. Topics include: microwave bipolar and field effect transistors, Gunn effect devices, avalanche effect devices, PIN diodes, mixer and detector diodes, and high electron mobility transistors. Prerequisites: EENG 576 and EENG 675.
4 credit hours

EENG 677 – OPTICAL COMMUNICATION SYSTEMS: A systems approach to the analysis and design of guided and unguided optical communication systems. The concepts include: photon statistics, detector characteristics, noncoherent and coherent detection of optical signals, receiver models, optical transmitters, link calculations, free-space system design, optical fiber fundamentals, and fiber communication system design. Prerequisites: EENG 530 and EENG 665. 4 credit hours

EENG 680 – MULTIDIMENSIONAL SIGNAL AND IMAGE PROCESSING: This course covers multidimensional signal and image processing. Topics include multidimensional Fourier transform, z-transform, discrete Fourier Transform, multidimensional infinite impulse response filters, multidimensional finite impulse response filters, and an introduction to the basics of image processing, restoration, and coding. This course will be taught at the level of Dudgeon and Mersereau's Multidimensional Digital Signal Processing supplemented by Lim's Two-Dimensional Signal and Image processing. Prerequisites: ENG 580 and MATH 521 and EENG 665. Winter Quarter
4 credit hours

EENG 681 – MULTIRATE AND WAVELET SIGNAL PROCESSING: This course covers multirate systems and wavelets with applications. The first portion of the course covers multirate systems and filterbanks, including decimation and interpolation, polyphase decomposition, M-channel filterbanks, perfect reconstruction, and lattice realizations. The second portion is an introduction to wavelet theory, including the lifting construction, wavelet recursion relations, convergence of wavelet series, continuous wavelet transforms theory, and the shift-invariant wavelet transform. Prerequisites: EENG 680. Spring Quarter 4 credit hours

EENG 682 – LEAST SQUARE ESTIMATION WITH SIGNAL PROCESSING APPLICATIONS: This course covers least square estimation with signal processing applications. Topics include least squares theory, algorithms and architectures for least squares estimation, together with one or more signal processing applications. Possible applications include linear prediction coding, spectral estimation, adaptive array processing, interference mitigation, and multisensor fusion. This course will be taught at the level of Giordano and Hsu's Least Square Es-

timation with Applications to Digital Signal Processing. Prerequisites: EENG 580 and MATH 521 and EENG 665.
4 credit hours

EENG 695 – VLSI SYSTEMS DESIGN: This course extends the fundamental concepts developed in EENG653 to larger scale VLSI systems. A hierarchical design methodology is developed using VHDL. A variety of subsystem elements are presented including arithmetic circuits, memory structures, control structures, and datapath components. Each student will complete a design project of moderate complexity including VHDL specification, layout, and design verification. The resultant design will be submitted for fabrication to be tested in conjunction with EENG795. Prerequisites: CSCE 492 and EENG 653 (Enrollment limited to U.S. citizens.) Winter Quarter
4 credit hours

EENG 700 – SEMINAR IN REMOTE SENSING AND COMMUNICATIONS SYSTEMS: This course is a student-participation seminar for students studying in the areas of antennas, propagation, electromagnetics, microwaves, communications, information and coding theories as applied to the broad areas of remote sensing and communications systems. Students are required to present research progress reports, analyzes of pertinent archival journal papers and conference papers, and tutorials on specialized topics related to their research. Students will also be required to practice drafting conference papers/presentations and journal papers that, when appropriate, may be submitted for possible publication. The goal of this course is to foster an awareness of the open literature and IEEE publication standards for papers and presentations. Prerequisites: None. Offered All Quarters
1 credit hour

EENG 708 – DESIGN OF LINEAR MULTIVARIABLE FEEDBACK SYSTEMS: This course covers the principles of linear multivariable feedback control systems, modeling and synthesis. Advanced topics in linear algebra provide the mathematical foundation needed to develop the control system design methods. The topics studied include system identification, the synthesis of regulators, the rejection of disturbances, and the tracking of multiple command inputs. The design of observers and their effect on system performance are studied. The design of this entire range of multivariable feedback systems is unified by the use of the methods of high gain system design using proportional plus integral controllers, entire eigenstructure assignment, and quantitative feedback theory using frequency domain methods. The design methods are equally applicable to both continuous-time and discrete-time systems. Prerequisites: EENG 510, EENG 660, and EENG 655
2-4 credit hours

EENG 710 – ADVANCED LINEAR SYSTEMS I: This is an advanced course in linear systems theory for the student wishing to delve more deeply into the fundamental concepts of linear systems. It will generally be taught on a seminar basis and topics will be selected from the current literature. Typical areas treated include decoupling and non-interactive control theory, singular perturbation theory and reduced order models, geometric analysis of linear systems, infinite dimensional linear systems, and other topics according to student and faculty interests. Prerequisites: EENG 510, EENG 660, and MATH 621. 4 credit hours

EENG 712 – Linear Estimation and Control: Development of discrete stochastic equations as models of dynamic systems. Bayesian estimation theory is used to develop the linear discrete prediction filtering and smoothing equations, and dynamic programming is used to derive the optimal control laws for stochastic control systems. Design, performance analysis, and practical aspects of implementation are emphasized, exploiting examples from aided navigation systems and air-to-air missile controller design. Prerequisites: EENG 510, EENG 562, and STAT 586. 4 credit hours

EENG 715 – Advanced Topics in Optical Information Processing: This course provides the methodology for the efficient design and planning of communications, imaging and other sensor systems which involve signals at optical frequencies. In a seminar environment topics of current research and Air Force operational systems are investigated. Topics to be covered will include: hybrid pattern recognition with invariances to position scale and rotation, optical preprocessing, multisensor fusion, optical free space communication, coherent optical fiber communication, phase retrieval in the context of laser radar illuminated scenes, optical phase conjugation, optical neural networks, general purpose optical information processing, and optical operational amplifiers. Prerequisites: EENG 672. 4 credit hours

EENG 716 – Imaging Through Turbulence: In this course the student is introduced to adaptive, speckle and hybrid imaging in the presence of the atmosphere. A collection of over 20 seminal papers as well as extensive faculty notes are used to introduce topics ranging from basic effects of atmospheric turbulence on optical propagation and conventional imaging to advanced imaging applications such as adaptive optical, speckle, and hybrid imaging. These advanced imaging applications are all techniques used to mitigate the detrimental effects of the earth's atmosphere on conventional imaging. Prerequisites: EENG 672. Summer Quarter 4 credit hours

EENG 717 – Advanced Topics in Microelectronic Devices: This course is a continuation of EENG 675. An associated processing technology laboratory provides students with hands-on experience in device fabrication. The subject matter in the course focuses on current Air Force problems. Topics include the reliability and degradation of integrated circuits, testing and evaluation of IC's, radiation damage and hardening of solid-state devices, compound semiconductors, charge control devices, electro-optic devices and magnetic bubble memories. Prerequisites: EENG 675. Spring Quarter 4 credit hours

EENG 718 – Advanced Topics in Pattern Recognition: This is an advanced course based on the current literature and technical reports. Applications of pattern recognition techniques are studied in relation to current Air Force research projects. Prerequisites: EENG 621 or Permission of Instructor. Fall Quarter 4 credit hours

EENG 725 – Advanced Electromagnetic Theory I: This course provides an advanced treatment of electromagnetic field theory. Advanced mathematical techniques including the use of Green's functions, transform theory, and contour integration are employed to study the behavior of static and dynamic electromagnetic fields in free space and material media. The course provides a complete development of the derivation and use of multi-dimensional scalar and dyadic Green's functions. Prerequisites: EENG 628. 4 credit hours

EENG 726 – ADVANCED ELECTROMAGNETIC THEORY II: This course involves advanced mathematical treatments of various topics in applied electromagnetic theory. Topics addressed include the use of vector wave functions for general coordinate systems, the T-Matrix method, and the Born and Ishimaru iterative methods for dielectric scattering. The use of perturbational and variational methods in the solution of electromagnetic problems is also examined. Asymptotic methods for evaluating scattering problems and deriving diffraction are given. The course includes an introduction to the Weiner-Hopf method. Prerequisites: EENG 725.
4 credit hours

EENG 727 – FREQUENCY SELECTIVE SURFACES: This course covers the theory of scattering by finite and infinite arrays of dipoles or slots in a ground plane surrounded by arbitrary stratified dielectric media, which form frequency selective surfaces (FSS). To analyze such structures, the periodic moment method is developed and applied with spherical, cylindrical and plane wave expansions for the electromagnetic fields. Alternative numerical methods are taught, with an emphasis on speeding up the necessary field computations without a significant loss of accuracy. Each numerical method is given with its unique regions of applicability and advantages relative to other methods. FSS design methodology is also taught, with issues such as the choice of dipole or slot shape and size, array packing density, and supporting dielectric sandwich structure addressed as to their impacts on the FSS's microwave filtering capability and its suitability for stealth applications. Students are given a series of homework assignments which illustrate such concepts as scan impedance, scan independence and conjugate impedance matching for radomes and phased array antennas. Students are required to develop a special purpose FSS analysis computer code and use it for an antenna/radome design project. Students are also required to write a short report on unclassified literature related to FSS research. Prerequisites: None. Summer Quarter 4 credit hours

EENG 735 – INERTIAL NAVIGATION SYSTEM ANALYSIS AND INTEGRATION: Optimal filtering theory is introduced and applied to the design of integrated navigation systems. The powerful properties of the Kalman filter are used to optimally combine the INS outputs with a variety of external measurements to extract superior navigation system performance. The Global Positioning System (GPS) mathematical and error models are derived and analyzed. Strapdown INS computational algorithms are derived. Emphasis is placed on computational algorithms and their error performance. A substantial class project focuses on the benefits of INS integration (aiding) with external measurements, such as from the GPS. Prerequisites: EENG 635,and EENG 712 or EENG 765. Summer Quarter
4 credit hours

EENG 737 – DIGITAL METHODS OF AEROSPACE GUIDANCE: This course presents modern digital techniques of ballistic missile guidance. Topics include implicit guidance, explicit guidance, targeting and error analysis for ballistic missiles, optimal control, and steering commands. Considerations required to achieve the ultimate objective of reaching the intended target are discussed. These interrelationships are further emphasized by performing a series of computer projects in which the elements of an overall missile guidance system are developed and simulated. A research paper is required to allow the student to focus on a specific topic associated with ballistic missile guidance. Prerequisites: EENG 510. 4 credit hours

EENG 738 – Digital Avionics Fire Control: This course applies modern optimal estimation and control theory to fundamental problems of avionics fire control and armament. The topics include: the application of Kalman filters to estimate the state of a maneuvering target using available sensor information, use of the target state estimates in pointing and tracking systems, the application of Kalman filters in transfer alignment, proportional navigation guidance, homing missiles, active guidance, and passive guidance. A research paper focusing on one of the course topics is required. Prerequisites: EENG 510 and EENG 712 or 765. 4 credit hours

EENG 742 – Synthesis of Optimal Control Systems: A study of the design and synthesis of optimal control systems, using calculus of variations, the maximum principle and optimal regulatory theory. Computational aspects, including gradient and second variation methods, are studied using hand examples and case studies from the current literature. Prerequisites: EENG 510 and EENG 562. 4 credit hours

EENG 743 – Literature Study in Control Theory: Topics selected based upon the current state-of-the-art control system literature; e.g., Quantitative Feedback Theory (QFT), methods of entire eigenstructure assignment, linear and nonlinear, analog and discrete systems, etc. The material for study is drawn from the current technical literature and textbooks. Students submit reports on theoretical developments and/or problem solutions in the area of interest. Prerequisites: EENG 510 and EENG 562 and Permission of Instructor. 1-4 credit hours

EENG 765 – Stochastic Estimation and Control I: Probability theory and stochastic process theory are investigated to develop practical system models in the form of linear dynamic systems driven by known inputs, disturbances, and uncertainty. Using this model, the optimal estimator (Kalman filter) is derived and studied. Design of practical on-line filters, including performance analyses and aspects of implementation on digital computers, is accomplished for various Air Force applications. Prerequisites: EENG 510, EENG 562, and STAT 586 or STAT 601. Winter Quarter 4 credit hours

EENG 766 – Stochastic Estimation and Control II: Topics in linear estimation beyond those in EENG 765 are considered: frequency domain methods, square root and U-D filtering, optimal smoothing, and the extended Kalman filter as a means of applying linear estimation theory to nonlinear problems. Nonlinear filtering is then developed in detail, followed by stochastic digital controller design and performance analysis. The need for, and practical application of, these concepts in Air Force weapon systems are fully developed. Prerequisites: EENG 765 or EENG 712. Spring Quarter 4 credit hours

EENG 768 – Stochastic Estimation and Control III: Selected topics in advanced design of filters and stochastic controllers for Air Force systems, including adaptive algorithms, system identification, computational and implementation enhancement, decentralized control and large scale systems are studied. Topics based upon current technical literature and Air Force research and development programs are examined. Prerequisites: EENG 766. Summer Quarter 4 credit hours

EENG 795 – ADVANCED TOPICS IN VLSI SYSTEMS: This course is a combination of a testing laboratory and an advanced topics class. The design projects which the student completed in EENG 695 will be tested both functionally and parametrically. The student will gain experience in both probing the circuit directly and using automated test equipment. The student will also have the opportunity to explore advanced topics in VLSI systems design in a seminar format. Such topics may include analog circuit design, gallium arsenide circuit design, computer-aided design theory, and new VLSI architectural concepts. Prerequisites: EENG 695. Spring Quarter
4 credit hours

EENG 799 – INDEPENDENT STUDY: Thesis research. Prerequisites: EENG 698 and Permission of Instructor.
1-12 credit hours

EENG 999 – DISSERTATION RESEARCH: Prerequisites: None. 1-16 credit hours

Department of Engineering Physics

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Department Head: Professor Robert L. Hengehold

Introduction

The Department of Engineering Physics offers programs in Applied Physics (M.S. and Ph.D.), Materials Science and Engineering, (M.S. and Ph.D.), Electro-Optics (M.S. and Ph.D.), Nuclear Engineering (M.S. and Ph.D.), Meteorology (M.S.), and Environmental Engineering and Science (M.S.).

The major areas of expertise in the department are:

(1) Nuclear Technology,
(2) Optical, Atomic and Molecular Physics,
(3) Semiconductor Materials and Photonics,
(4) Computational Physics,
(5) Lasers and Optical Systems, and
(6) Meteorology.

Faculty

Professors

Robert L. Hengehold (experimental solid state physics)

Glen P. Perram (laser physics, chemical kinetics, molecular spectroscopy)

Won B. Roh (electro-optics, nonlinear optics, phase conjugation)

Yung Kee Yeo (electrical and optical characterization of semiconductors)

Associate Professors

William F. Bailey (plasma physics, space physics)

Larry W. Burggraf (computational chemistry, materials science)

Kirk A. Mathews (computational nuclear engineering, nuclear weapons)

Heidi R. Ries (resonance spectroscopy)

Kenneth L. Schepler (AFRL professor - nonlinear optics)

Ronald F. Tuttle (measurement and signature intelligence)

David E. Weeks (computational chemical physics)

Paul J. Wolf (atomic/molecular physics, molecular spectroscopy)

Assistant Professors

Devin J. Della-Rose (space weather)

Gary R. Huffines (atmospheric physics, lightning)

Vincent J. Jodoin (nuclear weapon effects, nuclear proliferation)

Ronald P. Lowther (atmospheric physics, climatology)

Michael A. Marciniak (electro-optics, semiconductor lasers)

James C. Petrosky (radiation effects on materials)

Michael B. Scott (experimental solid state physics)

Michael K. Walters (atmospheric physics, modeling and simulation)

Emeritus Faculty

Charles J. Bridgman (nuclear weapon effects)

George John (Mossbauer spectroscopy, nuclear radiation detection)

Programs of Study

Applied Physics (GAP)

This program provides the student with a broad, graduate-level foundation in applied physics with specialization in engineering physics, optical physics, space physics, plasma physics, chemical physics, or materials physics. Laboratory techniques and computational methods are emphasized providing a balanced exposure to both experimental and theoretical practices. Students entering the Applied Physics Program should have an undergraduate degree in physics, engineering, meteorology, astronomy, or chemistry.

The core physics courses in this program are designed to provide the student with the necessary theoretical physics foundation. These core courses are generally selected from:

PHYS 600	Dynamics
PHYS 601	Electrodynamics I
PHYS 635	Thermal Physics
PHYS 640	Optics
PHYS 655	Quantum Mechanics I

The department offers specialization in the following areas:

OPTICAL AND LASER PHYSICS: This specialty covers the essentials of laser physics, laser devices, and optical detection. It prepares the student for positions involving research and development in directed energy weapons, high-energy lasers, semiconductor lasers, nonlinear optics, infrared surveillance and countermeasures, and optical imaging. The courses taken for this specialty are generally selected from: OENG 620, OENG 650, OENG 651, OENG 720, and OENG 780.

SOLID STATE AND SEMICONDUCTOR PHYSICS: This specialty provides the foundation for studies in solid-state physics, photonic devices, and optical properties of materials. It prepares students for positions involving the research and development of materials for electronic and photonic devices including semiconductor lasers, infrared sensors, smart seekers, lasers for rangefinders and target designators, and radar devices. The courses taken are generally selected from: PHYS 670, PHYS 671, MATL 672, OENG 720, OENG 775, and OENG 780.

SPACE PHYSICS: This specialty introduces the student to the effects of solar radiation and particle flux on the earth's ionosphere and magnetosphere with applications toward predicting space weather events. The focus is to provide an understanding of solar effects on the near-earth environment and their ramifications as to military systems and operations in space. The courses taken are generally selected from: PHYS 650, CHEM 675, PHYS 775, PHYS 776, PHYS 777, PHYS 791.

COMPUTATIONAL CHEMISTRY: This specialty prepares the student with the computational research tools used to predict the basic properties of new chemical species and materials. Quantum chemistry and molecular dynamics methods applicable to the design of new chemical systems for fuels, lubricants, explosives, rocket propellants, catalysts, and chemical defense agents are covered as are solid state modeling techniques employed in the development of new high performance materials for electronics, sensors, advanced rocket engine components, and biomedical applications. The courses taken are generally selected from: CHEM 620, CHEM 662, CHEM 750, and CSCE 790.

Nuclear Engineering (GNE)

This program provides the student with a broad foundation in nuclear engineering at the graduate level with an emphasis on nuclear weapon technology. A combination of coursework and laboratory practice provides the background for work involving nuclear detection, nuclear weapon effects, the nuclear fuel cycle, nuclear proliferation, and nuclear power. Students entering the Nuclear Engineering program should have an undergraduate degree in engineering, physics, or mathematics.

The nuclear engineering core courses are designed to give the student expertise in nuclear weapons and their effects, and they are selected from the following:

NENG 651	Nuclear Physics
NENG 650	Nuclear Instrumentation
NENG 605	Physics of Nuclear Explosives
NENG 631	Prompt Effects of Nuclear Weapons
NENG 635	Residual Effects of Nuclear Weapons

The department offers specialization in several nuclear areas including nuclear power systems; nuclear fuels; nuclear instrumentation and measurement; computational nuclear engineering; proliferation issues; and radiation effects, protection, and shielding.

Electro-Optics (GEO)

Electro-optics is a multi-disciplinary field requiring a background in electrical engineering coupled with knowledge of optics and laser technology. The graduate of this program is prepared to address technical problems in the combined areas of signal processing and optical engineering – for example, the technical problems associated with infrared and laser guided weapons, high-energy lasers, space surveillance, and active and passive target acquisition. As a result this program is under the joint supervision of the Departments of Engineering Physics and Electrical and Computer Engineering. Students entering the Electro-Optics program should have an undergraduate degree in electrical engineering.

A set of optical engineering courses covering the physics of the generation, propagation and detection of electromagnetic radiation form the core for study in electro-optics. These courses are typically chosen from the following:

OENG 620	Laser Engineering
OENG 650	Optical Radiometry and Detection
OENG 651	Optical Diagnostics Laboratory
OENG 660	Introduction to Nonlinear Optical Devices
OENG 780	Infrared Technology
OENG 775	Introduction to Photonic Devices
OENG 644	Linear Systems and Fourier Optics
OENG 720	Lasers and Applications

An electrical engineering specialty provides depth in a graduate electrical engineering area that complements the optical engineering core. The student selects these specialty areas from those offered by the Department of Electrical and Computer Engineering.

Meteorology (GM)

This program provides a broad foundation in meteorology at the graduate level with emphasis in atmospheric dynamics, analysis and forecasting, and physical meteorology. The program is designed to provide graduate meteorology education tailored to military applications. Laboratory practice is used extensively in the analysis and forecasting classes, and computational methods are emphasized in the dynamics and physical meteorology courses. Students entering this program should have an undergraduate background in meteorology or atmospheric science.

The core courses for this program are selected from the following:

METG 520	Introduction to Dynamic Meteorology
METG 530	Synoptic Meteorology
METG 610	Radiative Transfer
METG 620	Advanced Dynamic Meteorology
METG 630	Advanced Synoptic Meteorology

The department offers specialization in several areas of meteorology of particular interest to the military that include general meteorology; atmospheric dynamics; analysis and forecasting; and interactive computer graphics.

Materials Science (GMS)

The Materials Science and Engineering Program is a multidisciplinary program carried out in cooperation with the Materials and Manufacturing Directorate of the Air Force Research Laboratory. It is under the joint supervision of the Department of Aeronautics and Astronautics (Structural Materials) and the Department of Engineering Physics (Non-structural Materials). Students entering this program should have a background in engineering or physical science with an undergraduate knowledge of materials science and engineering. This program provides the student with the knowledge of materials science and engineering necessary for work in the fields of structural and non-structural materials for aerospace systems. The program produces graduates with a solid background in the fundamental areas of materials science and engineering, both structural and non-structural, an in-depth knowledge in one specialty area, experience in conducting and documenting an independent investigation, and writing a thesis on a problem of Air Force interest.

A set of five core courses provides a broad foundation in the theoretical and applied aspects of the fundamental areas of materials. This foundation is laid through a core of courses taken by all materials science and engineering students. The courses making up the core are:

MATL 545	Mechanical Properties of Materials
MATL 525	Thermodynamics and Kinetics of Materials
MATL 560	Electronic, Magnetic, and Optical Properties of Materials
MATL 680	Materials Characterization
MATL 685	Materials Selection and Processing

In addition, several specialty sequences are offered. Specialization in electronic and optical materials prepares the student for research and development of advanced materials for electronics, optical devices, advanced sensors, semiconductor lasers, and laser protection systems.

Environmental Science and Engineering (GES)

The Graduate Environmental Science and Engineering Program provides students with a foundation in environmental science and engineering, with specialization in areas such as remediation (hazardous waste engineering), air quality engineering, radiological engineering, and environmental materials analysis. Students entering this program should have a background in engineering or physical science with an undergraduate knowledge of chemistry.

The program is built upon an environmental science core, and these courses are chosen from among the following list:

CHEM 585	Aquatic Chemistry
CHEM 620	Materials Chemistry
CHEM 680	Atmospheric Chemistry
CHEM 685	Aquatic Organic Chemistry
ENVR 623	Environmental Toxicology
ENVR 625	Environmental Microbiology
NENG 651	Nuclear Physics
ENVR 640	Groundwater Hydrology and Contaminant Transport
ENVR 643	Environmental Transport Processes
EVSC 670	Atmospheric Transport

The department offers several specialty sequences, which expose the student to a combination of general environmental engineering, environmental monitoring, environmental analysis, environmental law, and risk analysis or modeling. These sequences are developed from courses selected from the EVSC courses offered by the Department of Engineering Physics and ENVR courses offered by the Department of Systems and Engineering Management. The student should refer to the Department of Engineering Physics Brochure for specific details.

Doctor of Philosophy (Ph.D.) Program

The Department of Engineering Physics offers studies leading to the award of a Ph.D. with concentrations in lasers, optics and optical systems, optical processing, semiconductor physics and devices, photonics, plasma physics and processing, materials science, chemical physics, transport theory, and nuclear engineering. Admission to the doctoral program requires a master's degree in physics or engineering.

The doctoral program is designed to provide graduates the capability of actively identifying, conducting, directing, and evaluating research at the frontiers of knowledge. The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for a range of defense technologies.

Facilities

The Department of Engineering Physics operates laboratories to support graduate instruction and research. The instructional laboratories complement courses of study in optics, lasers and optical diagnostics, optical observables, nuclear radiation detection and instrumentation, nuclear and environmental engineering, and meteorology. Research laboratories support faculty and student research at the M.S. and Ph.D. levels in laser spectroscopy, chemical physics, nonlinear optics, laser physics, ultra-fast spectroscopy, optical and electrical characterization of semiconductors, radiation effects in solids, Mossbauer spectrometry, nuclear radiation detection, nuclear weapon effects, environmental science, and atmospheric science. In addition, a class 10,000 cleanroom is available for fabrication of electronic and photonic devices.

Research

Optical, Atomic and Molecular Physics

Departmental faculty are actively engaged in both experimental and theoretical research in the areas of nonlinear optics, laser spectroscopy, chemical kinetics and molecular dynamics. Particular applications include novel laser devices, image processing, directed energy weapons, environmental science, ionospheric kinetics, remote sensing, atomic clocks, and high energy density materials. Current experimental programs are using laser-induced fluorescence, photolysis, phase conjugation techniques, Fourier transform spectroscopy, thin film deposition and laser ablation techniques, and chemical flow tube techniques to study the fundamental interactions between electromagnetic radiation and matter.

Computational Physics

The Department of Engineering Physics is actively pursuing research in computational fluid dynamics, computational electronics and nanoelectronics, and computational chemistry and materials science. The computational resources of AFIT have recently been significantly enhanced with the establishment of one of the four Major Shared Resource Centers of the Department of Defense at Wright-Patterson AFB.

Nuclear Technology

Research in nuclear technology includes both computational and experimental areas. The computational research involves development of computational tools for modeling nuclear systems, particularly radiation transport algorithms, and the analysis of nuclear systems and of nuclear measurements data. Experimental research involves measurements of radiation, radioactive materials, and other hazardous materials in the environment. Experimental applications include radiation detectors for nuclear fuels, optical spectroscopy of uranium oxides, nondestructive inspection of aircraft using gamma rays, Mossbauer spectroscopy of solid lubricants, measurement of metals uptake in micro-organisms, and radiation effects in semiconductors.

Semiconductor Materials and Device Characterization

The experimental solid-state physics group is conducting advanced research on optical and electrical properties of various semiconductor materials, heterostructures, quantum wells, multi-quantum wells and superlattices, such as GaAs, AlGaAs, GaAs/AlGaAs, GaSb, InAs/GaInSb, SiGe, SiGe/Si, and wide-bandgap materials, such as SiC and GaN. The objective of this research is to provide a better understanding of the characteristics of both the intrinsic and extrinsic semiconducting materials used for fabrication of various electronic and opto-electronic devices, as well as the devices themselves. Devices of interest are those applicable to photonic applications such as light emitting diodes, semiconductor lasers and optical and infrared detectors, as well as high temperature electronic devices.

Atmospheric Science

The master's degree research in atmospheric physics may be directed in several areas: transition of meteorological principles into weather forecasting aids, assistance to the Air Force weather community in validating proposed operational models, or examination of the possible operational relevance of newly published theories. The original "call for research" request resulted in nearly 100 responses. While most were from Headquarters, Air Weather Agency and its two centers, AF Global Weather Center and AF Combat Climatology Center, the responses from the operational sector were notable. Not only did a significant number of these proposed topics represent outstanding problems to be addressed as graduate research, in many instances, the results factored into the formulation of high-level decisions having immediate feedback on operations or the acquisition process.

Course Offerings

CHEMISTRY

CHEM 580 - FUNDAMENTAL ATMOSPHERIC CHEMISTRY: The chemistry and physics of the natural and polluted atmosphere are presented with an emphasis on fundamental processes and their implications for air pollution, monitoring and control. The foundation of chemical kinetics, atomic and molecular spectroscopy, and photochemistry are presented as a basis for analyzing rates and mechanisms of atmospheric reactions. Topics include characterization of the Earth's atmosphere, the effects of air pollution, combustion pollution sources, gas phase atmospheric chemistry, photochemical cycles for NO2, NO, O3, and CO, photochemical smog, stratospheric ozone, aqueous phase atmospheric chemistry and acid rain. Prerequisites: None. 4 credit hours

CHEM 585 - INTRODUCTION TO AQUATIC CHEMISTRY: This course provides students with a basic understanding of aquatic chemistry. Topics covered include kinetics thermodynamics, chemical equilibria, acid-base chemistry, complexation, precipitation-dissolution, oxidation-reduction reactions, organic chemistry, and solid-solution surface chemistry. Fundamental chemical processes are presented with their implications for practical applications to the natural and polluted aquatic environment. The course is taught with special emphasis on applications to groundwater pollution. Prerequisites: College General Chemistry Course or ENVR 550. Spring Quarter 4 credit hours

CHEM 590 - ENVIRONMENTAL CHEMISTRY: Students will study organic and inorganic chemistry, aquatic chemistry (water pollution and treatment, biochemistry), oxidation-reduction and phase interactions, atmospheric chemistry (air pollution, smog), soil chemistry, and hazardous waste and toxicological chemistry. Some material will be studied in detail while other material will be studied as a broad overview. This course and the text are designed for non-chemists, including engineers, managers, lawyers, etc.; it requires only a background in beginning chemistry. However, the course includes technical topics such as chemical reactions, reaction rates, equilibrium processes, and transport. This is a fundamental course which will provide a foundation for any environmental manager or engineer**.** Prerequisites: One Semester of College Chemistry. 3 credit hours

CHEM 675 - UPPER ATMOSPHERIC CHEMISTRY: This course focuses on the physics and chemistry of the upper atmosphere of which the ionosphere is a vital and integral part of this region. The principal ionization sources are photoionization and energetic particle collisions with ambient atoms and molecules. A variety of processes that operate in the upper atmosphere will be identified and related to input and output parameters by detailed mathematical and physical descriptions of the processes. This course should bridge the gap between elementary studies in the fields of physics and research literature in upper atmosphere physics and chemistry. Prerequisites: None. Spring Quarter 4 credit hours

CHEM 681 - NUCLEAR CHEMICAL ENGINEERING: Chemical engineering aspects of the military nuclear fuel cycles are studied to characterize weapon sources. This knowledge is then combined with a working knowledge of the current status of international nuclear proliferation to assess future trends. Topics include an overview of the nuclear fuel cycle including uranium mining and milling; 2) sources of plutonium including a detailed investigation of the properties of irradiated fuel, solvent extraction for fuel reprocessing, and the chemical and physical properties of plutonium and the actinides; an understanding of stable isotope separation with particular emphasis on uranium enrichment techniques; and tritium production and use in nuclear weapons. Some secret (RD) material is included. Prerequisites: NENG 651 and NENG 605 (Corequisite: NENG 650). Summer Quarter 4 credit hours

CHEM 720 - CHEMICAL KINETICS: Advanced level investigation of the rates and mechanisms of chemical reactions and energy transfer. Theoretical methods of Slater and RRKM are presented for the calculation of rate coefficients from fundamental properties. Current experimental methods used to study the kinetics of jet engines, rockets, lasers, plasmas, and the earth's atmosphere are discussed. Prerequisites: CHEM 520, AERO 729, or permission of instructor.
4 credit hours

CHEM 750 - COMPUTATIONAL CHEMISTRY AND MATERIALS SCIENCE LABORATORY: This computational laboratory will build on topics covered in MATL 662 through a series of four to five computational projects. Each project will explore a specific technique used in computational chemistry and materials science through the use of the computational facilities at the Major Shared Resource Center (MSRC). Prerequisites: MATL 662, CSCE 656.
4 credit hours

CHEM 781 - ADVANCED TOPICS IN NUCLEAR CHEMICAL ENGINEERING: An in-depth study of the chemical engineering aspects of the military nuclear fuel cycle with a focus on foreign plutonium separation, uranium enrichment processes, and the issue of nuclear weapon proliferation. Topics include detailed discussions of the properties of irradiated fuels, solvent extraction for fuel reprocessing and plutonium recovery, chemical and physical properties of plutonium and the actinides, and in-depth discussions of sources of enriched uranium from isotope separation. Separation techniques emphasized will include gas centrifuge, calutron, gas diffusion, aerodynamic techniques (becker nozzle and UCOR process), thermal diffusion, and others. Some of these tech niques are no longer used by the U.S. (not cost effective) but they may be technologically feasible for use by foreign countries. Some secret (RD) material is included. Prerequisites: CHEM 681. 4 credit hours

CHEM 825 – CHEMICAL PHYSICS: An advanced study in the area of chemical physics. Topics covered include the approximate solutions to the time dependent Schrodinger equation for reacting systems and for systems interacting with electromagnetic fields. The foundation of infrared and ultraviolet spectroscopy, angular momentum considerations, symmetry studies, and electronic states are included. Prerequisites: CHEM 720 or permission of instructor.
4 credit hours

CHEM 840 - ADVANCED CHEMICAL KINETICS: A seminar course covering the theoretical aspects of chemical kinetics, calculation of rate constants from a consideration of the fundamental properties of atoms and molecules, analysis of classical methods such as Slater or RRKM and introduction to quantum and statistical solutions involving the Louiville equation. Prerequisites: CHEM 720, CHEM 825 or permission of instructor.
4 credit hours

CHEM 850 - MOLECULAR ORBITAL THEORY: A study of the variational method as applied to the hydrogen molecule. Molecular orbitals are presented and mathematical methods for solving the wave equation for molecules are developed. The SCF, LCAO, and MO methods are developed. Group theory as applied to molecular orbital symmetry is presented. Ab initio and semi-empirical methods are discussed. Prerequisites: CHEM 825 or permission of instructor.
4 credit hours

ENVIRONMENTAL SCIENCE

EVSC 560 - ENVIRONMENTAL MONITORING: Sampling is an attempt to choose and extract a representative portion of a physical system from its surroundings. Environmental sampling is a complex subject which is different from and which has received less attention than analytical methods. But sampling itself is vitally important, as samples which are unrepresentative or unreliable are seldom worth the care and expense of laboratory analysis, nor can the best analytical techniques compensate for the systematic error unreliable samples may contain. The goal of this course is to encourage adequate consideration of the principal variables involved and special techniques needed in planning and carrying out reliable sampling of environmental matrices. Specific needs will dictate which approaches are incorporated in sampling plans and which are rejected. Prerequisites: Permission of instructor and CHEM 590 and STAT 526. Spring Quarter 4 credit hours

EVSC 650 - ENVIRONMENTAL MEASUREMENT TECHNIQUES: This course treats the proper application of the various chemical, physical, and thermophysical analytical methods that are used to characterize environmental samples. Techniques include: emission spectroscopy, atomic absorption spectroscopy, x-ray fluorescence analysis, neutron activation analysis, gamma-ray spectroscopy, wet analytical chemistry, gas chromatography, mass spectrometry, scanning electron microscopy, transmission electron microscopy, and x-ray diffractometry. Hands-on experience will be obtained in the associated laboratory. Prerequisites: CHEM 590 and STAT526.
4 credit hours

EVSC 666 - REMOTE SENSING OF ENVIRONMENT: This course considers techniques for remote sensing of atmospheric and water pollutants that use nearly the entire electromagnetic spectrum. As examples, airborne and satellite visible and infrared measurements are used to map oil spills and to monitor chemical effluents from facilities. Radiation source characterization and transport of that radiation through free space along with principles of optical detection are considered. Remote laser techniques for monitoring gaseous pollutants including infrared absorption, laser back-scatter (lidar), laser-induced fluorescence and Raman back-scatter are also treated. Prerequisites: CHEM 590. 4 credit hours

EVSC 670 - ATMOSPHERIC TRANSPORT: This course begins with the fundamental aspects of atmospheric physics and chemistry, which affect the dispersion of environmental effluents from industrial activities. Various aspects of atmospheric transport modeling are then presented. Included are an introduction to meteorological modeling and stack plume rise, followed by development of an Eulerian dispersion model, which is then simplified into a practical Gaussian plume model. Basic first-principle Gaussian plume models will be developed to enhance understanding of concepts. Prerequisites: CHEM 590 or CHEM 681, MATH 508.
4 credit hours

EVSC 671 - ADVANCED ATMOSPHERIC TRANSPORT: This course builds upon EVSC 670 focusing on the further application of EPA and Air Force regulatory air transport models with much hands on experience. This course begins with an in-depth look at dispersion and diffusion theory from which we develop the Gaussian plume model. Upon learning the limitations of this mathematical approach, the focus will

be directed to understanding and using Eulerian and Lagrangian atmospheric contaminant models to study current environmental issues not suitable for solution by simple Gaussian plume models. Prerequisites: EVSC 670, MATH 508, CHEM 680.
4 credit hours

EVSC 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: Department permission.
1-12 credit hours

MATERIALS SCIENCE

MATL 525 - THERMODYNAMICS AND KINETICS OF MATERIALS: Applications of thermodynamics and kinetics relevant to materials science and engineering are presented. Concepts treated include free energy of phases, phase diagrams, metastability, and applications to problems in solids and thin films. Thermodynamics is applied to pure materials, solid solutions, phase equilibria, interfaces and defects. Kinetics topics include diffusion in solids, nucleation kinetics, composition-invariant solid/solid interface migration, and kinetics of surface deposition. Prerequisites: Undergraduate Materials Science Course.
4 credit hours

MATL 560 - ELECTRONIC, MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS: Introduction to the theory and engineering applications of electronic, magnetic, and optical materials. Atomic bonding, crystal structure, crystal defects, lattice vibrations, band theory, metals, dielectrics, semiconductors, magnetic materials, ferroelectrics and superconductors are covered. Use of these materials in solid state devices, hard and soft magnets, superconductors, and optical devices are treated. Prerequisites: Undergraduate Materials Science Course. Fall Quarter
4 credit hours

MATL 620 - CHEMISTRY OF MATERIALS: A study of the electrochemistry, inorganic chemistry, organic chemistry, polymer chemistry and solid-state chemistry relevant to synthesis processing of materials. Computational methods of predicting and correlating materials structure with properties or alternative materials will be introduced. This course introduces the student to chemistry of materials and chemical processes which use or produce significant quantities of toxic chemicals. Emphasis will be placed on chemistry of materials and processes important in current and future aerospace manufacture and maintenance. This course provides background for understanding pollution prevention. Prerequisites: Corequisite CHEM 590.
4 credit hours

MATL 672 - OPTICAL PROPERTIES OF MATERIALS: Study of the various optical phenomena in materials; topics will be selected from absorption, reflection and emission processes, luminescence, dispersion theory, optical materials, polymers, wave propagation in anisotropic media, and nonlinear properties of materials. Applications will be made to the material requirements of optical devices such as lasers, detectors, etc. Prerequisites: PHYS 670. Summer Quarter
4 credit hours

MATL 701 - RESEARCH APPRENTICESHIP: Students will work on special problems related to an individual professor's or laboratory scientist's materials research program. These special problems will range from pedagogical problems intended to bring the student up to the state of knowledge to problems which represent immediate goals of a research program. The problems may be computational, experimental or theoretical and will vary depending upon the

needs of the student and the individual research interests of the professor or laboratory scientist. Prerequisites: Permission of the instructor.
4 credit hours

METEOROLOGY

METG 510 - PHYSICAL METEOROLOGY: Physical meteorology is concerned with atmospheric structure and composition. It examines a wide range of subjects: elementary kinetic theory of gases, 1st and 2nd laws of thermodynamics and how they pertain to the atmosphere, properties of aerosols and clouds, cloud physics, precipitation processes, and atmospheric electricity. Prerequisites: None. 4 credit hours

METG 520 - INTRODUCTION TO DYNAMIC METEOROLOGY: Provides a firm understanding of the basics of dynamic meteorology in preparation for the core of the graduate meteorology program. Course material will cover the fundamental principles of atmospheric motion through Chapter 5 of Holton. Topics include the theoretical development of the system of partial differential equations used to describe the state of the atmosphere, basic conservation laws, applications of the equations of motion, circulation and vorticity theory, and the planetary boundary layer. Prerequisites: None. Fall Quarter 4 credit hours

METG 530 - SYNOPTIC METEOROLOGY: Applies the theory of atmospheric motion to the science of weather forecasting. This course will focus on the description, analysis, and forecasting of large-scale weather systems around the world. Particular emphasis will be placed on techniques and applications to military meteorology. The lecture material will be applied to real time and past weather scenarios in the weather laboratory. Forecast preparation and map discussions will be an essential part of the weather laboratory. Prerequisites: None. Winter Quarter 4 credit hours

METG 610 - RADIATIVE TRANSFER: Covers topics in radiative transfer for ultra violet, visible, and infrared; including emission, absorption, scattering, and atmospheric refraction. The course begins with an overview of earth-sun, Maxwell's equations, and theory of blackbody radiation. Part of the time will be spent developing a simple two-stream radiation transfer model. Application of the theory will be examined in operational models, such as LOWTRAN and the Electro-optical Tactical Decision Aid. Prerequisites: METG 510. Winter Quarter
4 credit hours

METG 612 - CLOUD PHYSICS: Covers the theories of cloud formation, precipitation, and atmospheric electricity. Particular emphasis will be placed on lightning formation, detection, and its effects. Convective clouds and mesoscale storm systems will be discussed in detail to include the general structure, scale, and vertical motions within these storms. A computer based project will be included to help visualize the formation of clouds and the moisture in them. Prerequisites: METG 510. Summer Quarter
4 credit hours

METG 620 - ADVANCED DYNAMIC METEOROLOGY: Advanced Dynamic Meteorology will build on topics covered in METG 520. Topics will include development of quasi-geostrophic and ageostrophic systems, linear perturbation theory, baroclinic instability, and middle-atmosphere dynamics. Prerequisites: METG 520. Winter Quarter
4 credit hours

METG 622 - NUMERICAL WEATHER PREDICTION: Covers prediction of atmospheric motions by the numerical solution of the governing equations of motion using principals and theory of computational fluid dynamics. Topics include finite difference formulation and theory, and their application to solution of basic partial differential equations, stability analysis, various approaches to numerical solution of the linearized advection equation, and an introduction to spectral methods. This theory will then be applied through study of quasi-geostrophic barotropic and baroclinic models and primitive equation models. Prerequisites: METG 620. Summer Quarter
4 credit hours

METG 630 - ADVANCED SYNOPTIC METEOROLOGY: Combines theory from advanced dynamics and mesoscale meteorology to further the understanding of weather forecasting. Particular emphasis will be placed on techniques and applications to military meteorology. The lecture material will be applied to real time and past weather scenarios in the weather laboratory. Case studies will draw from scenarios occurring almost entirely outside the U.S. Forecast preparation and map discussions will be an essential part of the weather laboratory. Topics covered include forecasting the occurrence of turbulence, applications to electro-optics, and general aviation forecasting. Prerequisites: METG 530.Spring Quarter 4 credit hours

METG 632 - MESOSCALE METEOROLOGY: Covers the dynamics and physics of small-scale meteorological phenomena. Weather features on this scale range from a few tens of kilometers up to a few hundred kilometers. Phenomena discussed includes polar lows, frontogenesis and frontolysis, meso-scale convective complexes, gravity waves, mountain waves, and symmetric instability. Prerequisites: METG 530, METG 620.
4 credit hours

METG 634 - TROPICAL METEOROLOGY: This course will extend the theory of atmospheric dynamics to the tropics with an emphasis on forecasting. Phenomena discussed will include cumulous convection, cloud clusters, and mesoscale convection systems, tropical wave disturbances, including the 30-50 day, semi-annual and quasi-biennial oscillations. Again, particular emphasis will be placed on techniques and applications to military meteorology. The lecture material will be applied to real time and past weather scenarios in the weather laboratory. Forecast preparation and map discussions will be an essential part of the weather laboratory. Prerequisites: METG 530, METG 620. Winter Quarter
4 credit hours

METG 640 – CLIMATOLOGY: Examines the underlying causes of climate on global, regional, and local scales. Topics will include long-term weather patterns, dynamic climatology, physical climatology, and climatic change, with emphasis on military applications. Prerequisites: None. Winter Quarter
4 credit hours

METG 642 - RADAR METEOROLOGY: Covers the theory of remote sensing using radar. Particular emphasis will be given to current Doppler radar technology, interpretation techniques and forecasting. The algorithms used to generate radar products in the Weather Surveillance Radar-1988 Doppler (WSR-88D, NEXRAD) will be examined in relationship to meso-scale meteorological principles, covering phenomena such as turbulence, wind shear, meso-scale convective complexes, nocturnal jets, and severe weather. Prerequisites: METG 530, METG 610. Winter Quarter
4 credit hours

METG 644 - SATELLITE METEOROLOGY: Explores the often-overlooked usefulness of satellite imagery and data for the purpose of meteorological analysis and forecasting. The course will survey current and future remote sensing techniques and satellite interpretation; temperature, wind, aerosol, and water vapor profile retrieval; clouds and precipitation; earth radiation budget measurements; space environment measurements. Prerequisites: METG 530, METG 610. Winter Quarter
4 credit hours

METG 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: Department permission.
1-12 credit hours

NUCLEAR ENGINEERING

NENG 597 - NUCLEAR WEAPONS EFFECTS, TECHNOLOGY AND NON-PROLIFERATION: This course is designed to provide each student with an understanding of the effects of nuclear weapons (with specific emphasis on the differences between conventional and nuclear weapons), the technology necessary to produce nuclear weapons (emphasizing the nuclear fuel cycle) and the current status of international nuclear weapon proliferation. To accomplish this, the course investigates the energetics of nuclear weapons to develop an appreciation for the destructive forces inherent in nuclear weapons, and to lay a foundation for understanding their effects. Then the specific effects of, and differences between, the various classifications of explosions (i.e., Air, Surface, subsurface and high altitude bursts) are covered. This is followed by a look at the technology required to produce nuclear weapons, with specific emphasis on the nuclear fuel cycle (fuel enrichment processes). Finally, this knowledge is combined with a working knowledge of the current status of international nuclear proliferation to assess future trends. The course is restricted to U.S. citizens only. Prerequisites: None. Summer Quarter
4 credit hours

NENG 601 - RESEARCH APPRENTICESHIP: Students will work on special problems related to individual professor's research programs. These special problems will range from pedagogical problems intended to bring the student up to the state of knowledge to problems which are a part of the immediate goals of the program. The problems may be computational, experimental or theoretical. This will vary from professor to professor. Prerequisites: None.
4 credit hours

NENG 605 - PHYSICS OF NUCLEAR EXPLOSIVES: Elementary theory of fission and fusion explosive devices is taught. Diffusion theory is developed to examine the space-time variation of neutrons in fission devices. Criticality, yield and disassembly mechanisms are included. Methods of statistical physics including Maxwell-Boltzmann and Planck distributions are employed. In fusion systems, reaction rate production, radiation-loss balance and yield calculations are examined. Size, mass, density and temperature ranges for fusion burning are developed. Some Secret (RD) material is included. Prerequisites: NENG 651. Winter Quarter
4 credit hours

NENG 620 - NUCLEAR REACTOR THEORY AND ENGINEERING: This course presents nuclear reactor theory, building upon the coverage of nuclear physics (reactions, radiations, fission, etc.) from NENG 651 and the coverage of neutron diffusion, prompt fast criticality and prompt kinetics from NENG 605. Delayed and thermal neutrons are incorporated into the treatment of criticality and kinetics. Reactor dynamics are examined, including aspects of reactor core and system design which provide reactivity feedback for reactor control. Nuclear reactor engineering topics include thermal management, energy conversion, radiation shielding, and mechanical and structural aspects of reactor and system design. This course provides a broadened exposure to applications of nuclear science, and provides the necessary foundation for the study of space nuclear power and of the nuclear fuel cycle. Prerequisites: NENG 605, MATH 508. 4 credit hours

NENG 625 - Electromagnetic Pulse Effects: Source, propagation, and interaction of the electromagnetic pulse (EMP) generated by nuclear weapons are covered in this course. Source generation is developed in detail for the high altitude EMP, and the characteristics of other types of EMP (source region, hydrodynamic, system generated, etc.) are pointed out. Coupling of EMP to systems is examined starting with the discussion of topological models of shielding. External interaction is treated with prolate spheroid and stick models. Penetration through shielding surfaces is emphasized and quantitative methods for handling apertures are covered. General hardening methods are discussed, and examples of the analysis of realistic systems are given. Prerequisites: PHYS 531 (Corequisite: NENG 605). 3 credit hours

NENG 630 - Radiation Health Physics: This is a course in environmental health engineering, i.e. protection of the individual and population groups against harmful effects of ionizing and non-ionizing radiation. Focus will be on physical measurements of different types of radiation and radioactive materials, establishment of quantitative relationships between radiation exposure and biological damage, movement of radioactivity through the environment, and design of radiologically safe equipment, processes, and environments with the intent on assessing the radiological impact on man. This course will be useful to bioenvironmental engineers, environmental managers, radiation safety officers, nuclear research officers, or medical personnel who will have responsibility for managing radiation safety programs, managing environmental activities of bases which have nuclear sources (hospital, PMEL, or nuclear weapons) or who must interact in their environmental management jobs with the Department of Energy. Prerequisites: NENG 651 (Corequisites: NENG 650).
4 credit hours

NENG 631 - Prompt Effects of Nuclear Weapons: Topics include source, transmission and mechanisms of interaction of x-ray, blast, thermal, neutron and prompt gamma radiation. X-ray interactions include shock generation and propagation. The conservation equations of fluid dynamics are used to describe shocks. These same equations are applied to blasts in air and underwater shock. Shock "jump conditions" and scaling laws are derived and applied. Thermal transmission is examined. The heat transfer equation is used to study thermal interaction. Buildup factors and fits of transport calculations are employed to study neutron and gamma transmission. Various neutron and gamma interaction phenomena are studied. In the case of each effect, system response is examined, hardening techniques are surveyed, and design trade-offs are discussed. Some Secret (RD) material is included. Prerequisites: NENG 605. Spring Quarter
4 credit hours

NENG 635 - Residual Effects of Nuclear Weapons : Environmental radioactivity from natural, nuclear industry, and weapons fallout is treated. The emphasis is on weapon fallout, both local and global. Methods of fallout modeling are included for both ground dose and airborne crew dose. Helath physics fundamentals including mechanisms of biological response calculation of dose, body burdens and maximum permissible concentrations are also included. Seismic detection of nuclear explosions and worldwide detection systems are examined. Prerequisites: NENG 605. Summer Quarter 4 credit hours

NENG 650 - Nuclear Instrumentation: Radiation detectors and detection systems; characteristics, applications, and principles of operation of gas-filled detectors, scintillation detectors, semiconductor detectors; applications and principles of electronic components such as single and multichannel analyzers, pulse amplifiers, discriminators, scalers, etc. Counting statistics, probability and data reduction are examined. Prerequisites: NENG 651. Fall Quarter
4 credit hours

NENG 651 - Nuclear Physics: A graduate level introduction to nuclear physics for nuclear engineers. Emphasis is on general nuclear properties, decay modes and decay schemes, radioactive decay laws and applications, nuclear reactions and applications, and interactions of radiation with matter. Essential ideas of nuclear structure, nuclear forces, systematics of stable nuclides, and quantum characterization of nuclear levels are introduced. Sources and uses of nuclear data tabulations useful to the engineer are studied. Prerequisites: PHYS 556. Fall Quarter 4 credit hours

NENG 660 - Radiation Effects on Electronics: This course covers the fundamentals of damage mechanisms to electronic devices from gamma rays, neutrons and charged particles. The course starts with a review of solid state physics and an introduction to the physics of bipolar and metal-oxide-semiconductor (MOS) technologies. The differences between ionization and displacement damage resulting from irradiation are pointed out, and used as a foundation for understanding the effects of particular types of radiation. Neutron effects on bipolar devices are treated primarily as a result of carrier lifetime and mobility degradation. Annealing of neutron effects are discussed. Gamma ray effects on field-effect transistors (FETs), particularly the creation and effects of hole traps and interface states, are covered. The dependence of these effects on device parameters (e.g. oxide thickness) is explained. Transient radiation effects such as latchup, upset, and single-event upset (SEU) are examined. Prerequisites: MATH 506, PHYS 531, PHYS 670, NENG 605. Winter Quarter
4 credit hours

NENG 685 - Computational Nuclear Engineering: Develops numerical problem solving using case studies of problems encountered in nuclear engineering/weapons effects. Numerical methods employed may include differentiation and quadrature, root solving, linear algebra (particularly tridiagonal systems of equations), eigenvectors and eigenvalues, initial and boundary value problems in ordinary differential equations, and partial differential equations. Examples of typical problems studied are: temperature of a plasma given its energy density (iteration or root solving), radionuclide decay chains (initial value problem, system of ODE's), 1-d spatial dependence

of radiation diffusion (boundary value ODE eigenvalue/ eigenfunction problem), transient heat diffusion (PDE's). Prerequisites: NENG 605, MATH 504.
5 credit hours

NENG 705 - METHODS OF RADIATION TRANSPORT: The transport of x-rays, gamma rays and neutrons is examined by theoretical analysis and numerical methods. Diffusion theory is presumed from NENG 605; its relation to transport theory is considered. The Boltzmann transport equation is developed, including the multigroup energy formulation. The major numerical approaches (discrete ordinates and Monte Carlo) to its solution are developed. The methods are programmed and used to explore the behavior and relative advantages of the two approaches. Variance reduction, adjoint methods, anisotropic problems, time-dependent problems, and eigenvalue problems are introduced. Prerequisites: NENG 605, NENG 685.
4 credit hours

NENG 720 - NUCLEAR REACTOR SYSTEMS: A survey of current systems from a design point of view. An advanced course in that the prerequisites involve similar theory, both statics and kinetics, for explosive systems (NENG 605), some heat transfer (NENG 631) and a study of reactor effluents. The same theory and methods are applied to nuclear chain reactors in this course. Large civilian power production reactors, small military power reactors and space nuclear systems are examined. Safety, cost and performance are included. Prerequisites: NENG 605, NENG 631, NENG 635.
Winter Quarter 4 credit hours

NENG 721 - SPACE NUCLEAR POWER SYSTEMS: Current and future nuclear power systems such as radioisotope thermal generators, solid core, fluidized bed and gas core reactors are analyzed. Converter and heat rejection theory is studied and integrated with nuclear heat sources. One of the outstanding research issues for advanced nuclear space power systems is assigned as a group design project. Prerequisites: NENG 631, NENG 635.
4 credit hours

NENG 725 - MONTE CARLO METHODS OF RADIATION TRANSPORT: Monte Carlo calculational techniques introduced in NENG 705 are further developed, including such areas as: anisotropic cross-sections, continuous vs. group energy dependence, multidimensional geometries, and curvilinear coordinates. Variance reduction schemes and specialized estimators (used in production codes such as MCNP and MORSE) are examined. The technique is applied to problems of x-ray, neutron, and/or gamma ray transport in/from nuclear weapons. Other applications of Monte Carlo methods are considered. Prerequisites: NENG 705. 4 credit hours

NENG 785 - TOPICS IN COMPUTATIONAL NUCLEAR ENGINEERING: Advanced numerical problem solving techniques are examined in the context of problems encountered in nuclear engineering and/or nuclear weapons effects. State of the art numerical methods are adapted to the problems examined in the course. Numerical experiments are used to augment analysis in evaluating the stability, conditioning, accuracy, and efficiency of the resulting algorithms. Prerequisites: MATH 674 or NENG 685 or permission of instructor.
4 credit hours

NENG 790 - NUCLEAR SYSTEMS DESIGN: Students are assigned to groups for the purpose of conducting a design study on an open-ended problem. Students must mathematically model the problem and propose solutions. Solutions are evaluated against established objectives and realistic constraints such as cost, reliability, survivability, safety, human factors, ethics, and social impact. The best solution is then optimized. Recent class problems have included future terrestrial and space-based Air Force systems. Prerequisites: NENG 631.
4 credit hours

NENG 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: Departmental permission.
1-12 credit hours

NENG 816 - ADVANCED TOPICS IN NEUTRAL PARTICLE TRANSPORT: Problems in neutron, gamma ray and x-ray transport are formulated and solved. Emphasis is on numerical methods of solution of the Boltzmann equation. Topics introduced in NENG 705 are expanded and extended. Current topics from the literature are examined. Prerequisites: NENG 705.
4 credit hours

NENG 830 - ADVANCED NUCLEAR WEAPON EFFECTS: Examines in depth selected problems in neutron, gamma, x-ray, thermal and electromagnetic radiation and in shock, debris, blackout and Argus effects. Treats problems both experimentally and theoretically on the basis of the most recent literature and information available. Prerequisites: NENG 631.
4 credit hours

NENG 865 - RADIATION TRANSPORT: The transport of electromagnetic radiation in a scattering, absorbing, and/or emitting medium is presented. The equation of transfer is formulated mathematically; both analytical and numerical methods of solution are considered. Coupled radiation-hydrodynamic problems are considered. Advanced mathematical methods are employed. Emphasis is placed on methods applicable to the transport of x-ray and gamma radiation originating from a nuclear weapon. Prerequisites: NENG 705. 4 credit hours

NENG 999 - DISSERTATION RESEARCH: Prerequisites: Approval of research advisor. 1-12 credit hours

OPTICAL ENGINEERING

OENG 615 - OPTICAL OBSERVABLE REDUCTION: This course considers the overall problem of the reduction of optical observables. The course begins with an understanding of how aircraft are optically observable from the threat viewpoint. Design techniques are presented for increasing aircraft survivability by lowering optical observables. Prerequisites: OENG 650.
Winter Quarter 4 credit hours

OENG 616 - ELECTRO-OPTICAL SYSTEMS LABORATORY: A laboratory and lecture course which introduces laboratory techniques for the measurement of optical observables (emission or reflection of optical radiation from aerospace vehicles). The hour long lecture period each week is used to discuss the design of experiments, safe and practical laboratory techniques, and the communication (in written and oral form) of experimental results. The experiments are in the areas of spectroradiometry, optical cross-section measurement, TV sensors, and IR sensors. Prerequisites: OENG 650. Summer Quarter
4 credit hours

OENG 620 - LASER ENGINEERING: Treats the basic operation and components of the laser with emphasis on the knowledge required to use the laser as an optical system component. Covers laser media, resonator, pump and waste heat removal as well as types of lasers available. Both CW and pulsed lasers will be treated. Stress will be placed on the laser output beam and the device parameters which affect that beam. Prerequisites: PHYS 640. Spring Quarter
4 credit hours

OENG 650 - OPTICAL RADIOMETRY AND DETECTION: Radiation source characterization and the transport of that radiation through free space is considered in the first half of this course. In the second half, the principles of optical detection are considered along with specific application of various types of detectors. To aid in the integration of the two parts of the course, the student will design a simple radiometer based upon the requirements of a specific mission. Prerequisites: PHYS 556, PHYS 640. Spring Quarter
4 credit hours

OENG 651 - OPTICAL DIAGNOSTICS LABORATORY: An advanced laboratory and lecture course in optical diagnostic techniques. The lecture phase of this course treats radiometry, optical sources, spectroscopic techniques, detector physics and performance, error analysis and laser safety. The laboratory experiments emphasize the design of optical systems for the purpose of analyzing physical phenomena. Typical experiments include: diagnostics of CW and pulsed laser systems, spectroscopic analysis of the luminescence from solids and plasmas, interferometric measurements, holography, and calorimetry. Prerequisites: PHYS 542, PHYS 670, and OENG 620. Summer Quarter 4 credit hours

OENG 660 - INTRODUCTION TO NON-LINEAR OPTICAL DEVICES: This course is designed to develop those areas of electromagnetic wave interaction with matter necessary for an understanding of nonlinear optical devices. Plane wave propagation in anisotropic media, commonly called "crystal optics," is stressed. Passive optical devices, such as waveplates, polarizers and compensators, are designed. Parametric processes are introduced and applications such as amplitude and frequency modulation, second harmonic generation, and parametric oscillation are considered. Prerequisites: PHYS 640; PHYS 601. Winter Quarter
4 credit hours

OENG 720 - LASER DEVICES AND APPLICATIONS: Treats specific laser systems of importance to the Air Force. The course stresses current laser technology, engineering analysis and laser system design. Topics typically covered include: design of electrically excited, chemical, and free electron, high-energy lasers, unstable optical resonators, propagation of high-intensity laser beams, laser interaction with materials, laser rangers and designators. The course includes classified material. Prerequisites: OENG 620. Winter Quarter
4 credit hours

OENG 740 - OPTICAL SYSTEM DESIGN: This course is designed to introduce the basic principles of computer-aided optical system design. Topics include basic principles of optical ray tracing (both geometric and analytic), chromatic aberrations, third-order Seidel aberrations, techniques for reducing these aberrations, current computer optical design programs, Gaussian beams, and modulation and scanning techniques. The course concludes with a design project of an optical system using a state-of-the-art computer optical design code. Prerequisites: PHYS 640. 4 credit hours

OENG 775 - INTRODUCTION TO PHOTONIC DEVICES: Provides an introduction to photonic components and devices, focusing on their basic principles of operation and applications. This course covers the basic components which are used in photonic devices: dielectric waveguides, semiconductor lasers including distributed feedback and quantum well lasers, semiconductor detectors, acousto-optic modulators and fiber optics. Specific photonic devices are covered including directional couplers, phase modulators, intensity modulators, photonic switches, bistable optical devices, and self-electro-optic-effect devices. Prerequisites: PHYS 570, PHYS 640, OENG 620. Summer Quarter 4 credit hours

OENG 780 - INFRARED TECHNOLOGY: This course presents the principles and technology required for the design and analysis of electro-optic systems, with emphasis on those systems operating in the infrared. Topics include sources of radiation, targets and backgrounds, atmospheric propagation, optics, detectors, detector performance criteria, scanning and tracking techniques. The course concludes with the design of a representative IR system such as an imaging system (FLIR) or a tracking system. Prerequisites: OENG 650. Winter Quarter 4 credit hours

OENG 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: Departmental permission. 1-12 credit hours

OENG 999 - DISSERTATION RESEARCH: Prerequisites: Approval of research advisor. 1-12 credit hours

PHYSICS

PHYS 519 - THE SPACE ENVIRONMENT: The near-earth environment, from the surface to geosynchronous altitude, is that in which satellites and astronauts must operate. This course is concerned with the radiation, particles, and general conditions encountered in the Earth's atmosphere, ionosphere, and magnetosphere. Specific effects that may be studied include spacecraft thermal equilibrium, orbit decay, spacecraft charging, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena. Prerequisites: None. Fall Quarter 4 credit hours

PHYS 520 - LASERS FOR ENGINEERS: A basic course in lasers for the non-specialist. The course is designed to give the student the concepts and vocabulary needed to understand the advances and applications discussed in trade journals and to enable the student to knowledgeably read a laser specification sheet. The course treats basic properties of laser light, the laser medium and cavity, characteristics of the laser output, types of lasers currently available, and selected applications. Prerequisites: None 4 credit hours

PHYS 521 - SPACE SURVEILLANCE: This course covers the fundamental physics necessary for an understanding of the remote sensing process with an emphasis on visible light and infrared systems. Beginning with the sources of electromagnetic radiation, the following aspects of the problem are treated phenomenologically: the interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors. Where appropriate, examples are chosen from current Air Force technology. Prerequisites: None. Winter Quarter 4 credit hours

PHYS 531 – Electromagnetism: An intermediate level course stressing basic principles of electromagnetic field theory. Treats electrostatics, Maxwell's equations, good conductor and good dielectric approximations, and wave propagation through interfaces. Poynting's theorem and the flow of power are covered. Waveguides and simple radiating systems are introduced. Prerequisites: MATH 504. Fall Quarter 4 credit hours

PHYS 542 - Optics Laboratory: A fundamental laboratory course with experiments on coherence, diffraction, lenses, interference, polarization and lasers. Lectures will introduce selected topics in laboratory practice such as error calculation, radiometry, spectrometry, coherence, and detectors. Prerequisites: PHYS 640. Spring Quarter 2 credit hours

PHYS 556 - Introduction to Quantum Physics: Basic mathematical and conceptual principles of quantum physics. Includes black body radiation, photoelectric effect, Rutherford scattering, Bohr theory of the atom, wave-particle duality, Schroedinger wave equation and applications, one electron atom, atomic spectra, X-rays, periodic table, statistical physics, statistical distribution functions. Prerequisites: None. 4 credit hours

PHYS 570 - Physics of Solid State Devices: Basic solid state physics for the non-physicist who needs an understanding of solid state devices. Topics include quantum theory, quantum statistics, crystal structure and binding, reciprocal lattice, crystal lattice dynamics, free electron theory, energy band theory, and semiconductors. Prerequisites: PHYS 556. Fall Quarter 4 credit hours

PHYS 598 - Engineering Physics Seminar: This seminar, offered once a week, normally during the third quarter, is designed primarily to provide students in the Department of Engineering Physics with the information they need to carry out their thesis research and complete the thesis document. Topics covered include the student-advisor relationship, literature surveys, research prospectus, the thesis document, grading standards, and the thesis defense. Prerequisites: None. Spring Quarter 1 credit hour

PHYS 600 – Dynamics: Treatment of theoretical mechanics at the advanced level. Develops Lagrangian and Hamiltonian formulations of dynamics from variational principles. Applications include central force problems, rigid body motion by matrix transformations, coupled oscillators. Prerequisites: MATH 504. Fall Quarter 4 credit hours

PHYS 601 - Electrodynamics I: A course in classical electromagnetic radiation. Treats wave propagation in space and in material media, reflection and refraction, and radiating systems. Prerequisites: PHYS 531 (Corequisite: MATH 504). Fall Quarter 4 credit hours

PHYS 635 - Thermal Physics: Treats statistical mechanics and thermodynamics. Topics include statistical methods, statistical thermodynamics with applications, ensemble theory, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics with applications. Prerequisites: PHYS 556. Winter Quarter 4 credit hours

PHYS 640 – OPTICS: Introduction to modern optics, with a treatment of both geometrical and physical optics. Geometrical topics include reflection and refraction, lenses, mirrors, stops, ray tracing, telescopes, and optical instruments. Wave phenomena treated will include interference, optical testing, polarization, and Fraunhofer and Fresnel diffraction. Prerequisites: None. Fall Quarter 4 credit hours

PHYS 644 - LINEAR SYSTEMS AND FOURIER OPTICS: This course covers the linear systems approach to modeling optical wavefront propagation, diffraction, and imaging. Introductory material includes analysis tools and two-dimensional Fourier transforms. The majority of the course is devoted to using these tools to solve problems in optics imaging, and optical information processing. Prerequisites: PHYS 640. Winter Quarter 4 credit hours

PHYS 650 - KINETIC THEORY OF PLASMAS: Study of the basic concepts and definitions of plasma physics and the parameters which characterize plasma behavior. Applications of the Boltzmann equation and kinetic theory to such basic plasma phenomena as Debye shielding, plasma waves, magnetic confinement, and ionospheric physics. Current applications in laser physics, gaseous electronics, and power generation are discussed. Prerequisites: PHYS 601. Spring Quarter 4 credit hours

PHYS 655 - QUANTUM MECHANICS I: An introduction to the Schroedinger approach to quantum mechanics. Presentation and analysis of experimental background, postulatory basis and perturbation methods. Application of theory to linear oscillator, free particle, hydrogen atom, hydrogen molecule and tunnel effect are presented. Prerequisites: PHYS 556. Fall Quarter 4 credit hours

PHYS 661 - ATOMIC AND MOLECULAR SPECTROSCOPY: Treats selected topics in atomic and molecular physics. Includes spectroscopy of atomic systems, diatomic and triatomic molecules, line shape, line broadening and interaction of radiation fields with matter, particularly in lasers. Approximation methods in quantum mechanics are applied to the spectroscopy of complex atoms and molecules. Analysis of electronic, vibrational and rotational experimental data is emphasized. Prerequisites: PHYS 655. Winter Quarter 4 credit hours

PHYS 665 - NUCLEAR PHYSICS: Topics include static properties of nuclei including electric quadrupole and magnetic dipole moments, nuclear forces, quantum mechanical formulation of nuclear scattering and cross sections, nuclear shell model, the collective model, gamma decay and transition probabilities. Prerequisites: PHYS 655. 3 credit hours

PHYS 670 - INTRODUCTION TO SOLID STATE PHYSICS: Study of fundamental concepts in solid state physics. Topics include crystal structure and binding, X-ray diffraction and reciprocal lattice, lattice vibrations and phonons, free electron Fermi gas, transport properties of metals, quantum theory of electrons and energy bands, semiconductors and semiconductor devices. Prerequisites: PHYS 635, PHYS 655. Spring Quarter 4 credit hours

PHYS 671 - SELECTED TOPICS IN SOLID STATE PHYSICS: Study of various phenomena in solids; topics will be selected from semiconductors and semiconductor devices, optical and surface phenomena, transport properties, super-conductivity. Prerequisites: PHYS 670. 4 credit hours

PHYS 730 - ELECTRODYNAMICS II: A continuation of PHYS 601 into areas appropriate for the study of microwave devices and electromagnetic pulse effects. Also includes relativistic particle dynamics, bremsstrahlung and waves in a magneto-ionic medium. Prerequisites: PHYS 601. Fall Quarter
4 credit hours

PHYS 735 - STATISTICAL PHYSICS: Development of tools for the description of macroscopic systems based on microscopic insights. The physics of critical phenomena including superconductivity in the Landau-Ginzburg theory, mean field theories, renormalization group, cluster expansion and path integral approaches, and Monte Carlo techniques are developed. Elements of non-equilibrium statistical mechanics including Onsager's theorem and the method of maximum entropy are also introduced. Prerequisites: PHYS 635. Winter Quarter
4 credit hours

PHYS 751 - PLASMA DYNAMICS: Expands the development of plasma physics beyond the basic phenomena discussed in PHYS 650 to include derivations of the Vlasov, Boltzmann, and Fokker-Planck equations. These equations are applied to plasma problems which illustrate collision dominated and collisionless plasmas. Plasma oscillations, dispersion relations, Landau damping and velocity space instabilities will be included in a study of plasma confinement and gas discharges. Prerequisites: PHYS 650.
4 credit hours

PHYS 755 - QUANTUM MECHANICS II: An intermediate quantum mechanics course which develops the formal mathematical basis and postulates of quantum mechanics. Examine topics in measurement theory, two level systems, scattering, spin and quantum dynamics and perturbation theory. Applications in atomic, molecular, and nuclear physics are developed. Prerequisites: PHYS 655. Winter Quarter
4 credit hours

PHYS 756 - QUANTUM MECHANICS III: Advanced quantum mechanics treating selected topics such as applications of group theory to quantum systems, systems of identical particles, and scattering theory, and molecular orbital theory. Applications to spectroscopy, chemical kinetics, and solid state physics are presented. Prerequisites: PHYS 755. 4 credit hours

PHYS 770 - SOLID STATE PHYSICS I: First course in a sequence of courses covering topics in solid state physics at an advanced level. Topics include free electron theory, crystal structure, x-ray diffraction, reciprocal lattice, electron dynamics, energy band calculations, transport theory, Fermi surfaces, band structure of metals, electronic scattering and cohesive energy. Prerequisites: PHYS 670, PHYS 755.
4 credit hours

PHYS 771 - SOLID STATE PHYSICS II: Second course in a sequence of courses covering solid state physics at an advanced level. Topics include lattice dynamics, phonons, anharmonic effects, dielectric properties, semiconductor properties, defects, magnetism, and superconductivity. Prerequisites: PHYS 770. 4 credit hours

PHYS 772 - SOLID STATE PHYSICS III: An in-depth study of advanced topics in solid state physics. Special emphasis will be given to the topics covering the optical properties and optical processes in semiconductors, dealing with the interactions among photons, electrons, holes, and impurities in semiconductor crystals. Topics include energy states, radiative and non-radiative transitions, emission and absorption processes in semiconductors, p-n junctions, and photovoltaic effects on semiconductors. Prerequisites: PHYS 756, PHYS 771, PHYS 730.
4 credit hours

PHYS 775 - IONOSPHERIC ELECTRODYNAMICS: The basic fluid and electrodynamic equations appropriate for the weakly-ionized plasma of the earth's ionosphere are derived and steady-state forms of these equations as well as linear instability theory are applied to operationally-relevant ionospheric phenomena. Representative phenomena may include: E and F-region dynamo theory; equatorial "spread F" and the General Rayleigh Taylor (GRT) instability; the Equatorial Anomaly; mid-latitude nocturnal plasma drifts; intermediate layers and the F-region valley; sporadic E and tidal/gravity waves; high-latitude plasma convection; radiowave scintillation. Prerequisites: PHYS 635, PHYS 650. Summer Quarter
4 credit hours

PHYS 776 - STRUCTURE AND DYNAMICS OF THE MAGNETOSPHERE: Physics of solar wind, formation of the magnetosphere, and properties of magnetosphere. Topics include solar wind flow, solar wind-earth magnetic field interaction, magnetosphere plasma-wave interactions, Van Allen belts, auroral phenomena. Prerequisites: PHYS 531, PHYS 650. Summer Quarter
4 credit hours

PHYS 777 - THE SOLAR ATMOSPHERE: This course deals with the source of the earth's space weather - the sun. In particular, the student will study the outer solar regions including the "quiet" photosphere, the chromosphere, the corona, and solar wind. The course heavily emphasizes both descriptions of instrumentation and data used to observe solar conditions and the "active" sun which perturbs the earth's environment, and it is intended to provide the space environment student with a quantitative description of solar events that impact the forecaster's mission. Class discussion will focus on sunspot activity, flares, prominence, coronal mass ejections, coronal holes, and other pertinent observables that indicate active conditions on the sun's surface. Prerequisites: PHYS 531, PHYS 635, PHYS 650, CHEM 675. Winter Quarter
4 credit hours

PHYS 781 - LASER SPECTROSCOPY: A first course in laser spectroscopy designed to provide the student with the fundamental principles underlying modern spectroscopic methods utilizing lasers. Topical coverage includes the discussion of elements of radiation physics relevant to laser spectroscopy, characteristics of lasers as a spectroscopic tool, and spectroscopic instrumentation including various detection techniques. These topics are followed by discussion of selected experimental techniques such as laser induced fluorescence, laser Raman, and two-photon absorption spectroscopy. Prerequisites: PHYS 661, OENG 651.
4 credit hours

PHYS 782 - SELECTED TOPICS IN NONLINEAR OPTICS: An advanced course in nonlinear optics designed to provide the student with the fundamental principles underlying nonlinear optical phenomena. Topical coverage includes the discussion of nonlinear interaction of light with matter in terms of nonlinear susceptibility. A semiclassical theory of nonlinear susceptibility is also included. These topics are followed by discussion of applications in selected subject areas in nonlinear optics and/or laser spectroscopy, such as frequency conversion, phase conjugation, stimulated Raman and Brillouin scattering, and coherent anti-Stokes Raman spectroscopy. Prerequisites: OENG 660, OENG 620, PHYS 755. 4 credit hours

PHYS 790 - ENGINEERING PHYSICS DESIGN: Treats the principles involved in the design of systems in the areas of optics, solid state physics, plasma physics and others. The student will participate in an engineering design study in one of these areas. Classified papers may be included. Prerequisites: Permission of instructor. 4 credit hours

PHYS 791 - OPERATIONAL ASSESSMENT IN THE SPACE ENVIRONMENT: In the first part of this course, students will study the current operational aspects of USAF/NOAA space environmental forecasting and observing. Students will then attempt to solve a current or future DoD operational space-environment-related problem through a class design study. Possible examples include: improving satellite-anomaly analysis procedures; writing satellite-anomaly case studies; designing a space environment monitoring network to meet future DoD requirements; developing a solar-event forecasting expert system. Prerequisites: PHYS 775, PHYS 776. 4 credit hours

PHYS 798 - DEPARTMENTAL SEMINAR: This seminar is offered once a week throughout the year for all students in doctoral and masters' programs in the Department of Engineering Physics. This seminar is intended to provide the student with information on a wide range of topics from current scientific research to practical engineering design. Where possible, the focus is on specific AF needs and programs in areas related to their studies and the structure and organization of the R&D community within the AF. This series is also used for faculty to present possible areas for student research and for students, particularly doctoral candidates, to present progress reports on their own dissertation research. Prerequisites: None. Offered all quarters 1 credit hour

PHYS 799 - INDEPENDENT STUDY: Thesis research. Prerequisites: Departmental permission. 1-12 credit hours

PHYS 840 - ADVANCED TOPICS IN OPTICS: Selections from a host of advanced topics such as the use of variational principles in geometrical optics, Fresnel-Kirchoff scaler diffraction theory, coherence, holography, imaging theory, interaction of light with materials and waves, dielectric waveguides and optical fibers. Prerequisites: PHYS 644, OENG 620. 4 credit hours

PHYS 845 - QUANTUM OPTICS: A modern introduction to light and its interaction with matter in terms of semi-classical and fully quantum mechanical analysis. Treats the photon concept and the fundamental physics which underlie modern optical phenomena such as self-induced transparency, photon-echo, coherent pulse propagation, Lamb's theory of the laser and super radiance. Prerequisites: PHYS 640, PHYS 755, OENG 620. 4 credit hours

PHYS 898 - DOCTORAL RESEARCH SEMINAR: A weekly seminar treating current areas of Air Force research of interest to faculty and doctoral candidates in the Engineering Physics Department. This is a participatory seminar in which student presentations comprise the bulk of the course. Prerequisites: Permission of department.
1 credit hour

PHYS 998 - RESEARCH PROSPECTUS: This course is designed to provide direction to the doctoral student in the development of the research prospectus. The student will work with his research committee in carrying out a background study in the area chosen for dissertation research, scope the problem and finally present the problem to the committee in a formal document, the Research Prospectus. If necessary this course can be repeated in several quarters depending on the nature and scope of the dissertation research. Prerequisites: Permission of department. Credits to be assigned

PHYS 999 - DISSERTATION RESEARCH: Prerequisites: Approval of a research advisor. 1-12 credit hours

Department of Mathematics and Statistics

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Introduction

The Department of Mathematics and Statistics offers graduate programs leading to a Master of Science (M.S.) in applied mathematics and a Doctor of Philosophy (Ph.D.) degree. Specialization can be in any of the areas of analysis, statistics, or numerical analysis.

Faculty

Professors

James M. Horner (special functions)
Alan V. Lair (partial differential equations)
Mark E. Oxley (functional analysis, partial differential equations)
Dennis W. Quinn (partial differential equations, bioinformatics)

Associate Professors

William P. Baker (asymptotic and perturbation methods)
Aihua W. Wood (partial differential equations, electromagnetic scattering)

Assistant Professors

Lawrence K. Chilton (finite element analysis)
John S. Crown (adjunct, statistics)
Thomas F. Reid (stochastic processes)
Daniel E. Reynolds (statistics)
Edward D. “Tony” White, III (statistics)

Instructors

R. Nicole Benton (statistics, queuing theory)

Emeritus Faculty

Wilhelm S. Ericksen (tensor analysis)
Albert H. Moore (probability)

Programs of Study

Applied Mathematics (GAM)

The aim of this master’s degree program is to provide a balanced foundational education in mathematical and statistical analysis, an understanding of appropriate applications of the theory, and some depth in an area of specialization. The program is designed for students who have completed an undergraduate major in mathematics or statistics. However, students with a strong record in mathematics while majoring in a science or engineering discipline will usually find their preparation to be adequate.

The core courses common to all Applied Mathematics MS degree options are STAT 537 (Introduction to Statistics), STAT 696 (Applied Linear Models), MATH 601 (Complex Analysis), and either MATH 600 (Mathematical Analysis) or MATH 602 (Modern Applied Mathematics I). The student will specialize in analysis, statistics, or numerical analysis by taking three courses within the specialty area. The department believes that the applied nature of the program is enhanced by interaction with at least one other department in the Graduate School of Engineering and Management. Therefore, an application sequence (minimum of eight hours) taken from another department is required, and serves to help the future applied mathematician gain an appreciation for communicating with other scientists and engineers. In addition, the thesis project is invariably linked to an Air Force or defense department organization, further enhancing the student’s appreciation for and experience in working with the non-mathematician.

Doctor of Philosophy (PhD) Program

The Department of Mathematics and Statistics offers studies leading to the award of a Ph.D. with concentrations in analysis, statistics, and numerical analysis.

The aim of the doctoral program is to provide comprehensive knowledge of existing theory and how it applies to problems in science and engineering along with the opportunity to extend the world's knowledge significantly beyond those bounds. A student seeking a Doctor of Philosophy should have a master's degree in mathematics, statistics, or engineering.

Being an applied program, particular emphasis is placed on educating students to recognize the relevance of analytical and numerical methods to the solution of specific problems and to enable them to develop new methods when they are needed. The education aims to produce an applied mathematician with the ability to develop new theoretical results and apply them as the need arises. Central to this goal is the research part of the program. Both the ability to conduct the research successfully and to report it in a coherent and fully documented dissertation is essential to the program. The program is kept sufficiently flexible, however, to permit students to develop their own specific interests.

Research

Research topics typically fall into the following broad categories: numerical analysis, partial differential equations, and statistical analysis. Many research efforts span these categories, using analysis and techniques from more than one area. Examples of such efforts, which have received funding from external sources recently, include bioinformatics, electromagnetic scattering, and fluid flow.

Course Offerings

MATHEMATICS

MATH 291 – MATHEMATICS REVIEW FOR ENGINEERING MANAGERS: Preparatory course in which the student reviews and studies mathematical prerequisites required for the core courses in graduate logistics programs. This course establishes competence with standard material in differential and integral calculus, including multivariable calculus. Prerequisites: None. Fall Quarter 4 credit hours

MATH 501/502 – MATHEMATICS FOR THE OPERATIONSAL SCIENCES I AND II: This two-quarter course sequence is designed for students in the curricula of graduate operations research and graduate operational analysis. The courses attempt to present the fundamental mathematical background necessary for advanced study in areas dealing with qualitative and quantitative analysis of operational/management systems. Prerequisites: None. Fall/Winter Quarters 4 credit hours

MATH 504 – DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS: This course builds proficiency with series solutions for ordinary differential equations with variable coefficients in the complex plane. It provides specific information on Bessel, Legendre functions, Laguerre and Hermite polynomials. Other special functions of mathematics are introduced including gamma and beta functions. The course covers the needed topics in complex variables such as analytic functions, singularities, power series expansions, contour integration and residue theory. Prerequisites: None. Fall Quarter 4 credit hours

MATH 505 – INTERMEDIATE DIFFERENTIAL EQUATIONS: This course is an introduction to systems of differential equations and is divided into three major parts. The first part is a study of first order linear systems of ordinary differential equations including matrix analysis, fundamental matrix solutions, elementary stability analysis, and applications. The second part is a study of nonlinear two-dimensional autonomous systems including phase plane analysis, elementary Liapunov stability, limit cycles and the Poincare-Bendixson Theorem. Finally, the existence of solutions to nonlinear initial value problems is established using the contraction mapping theorem. Prerequisites: None.
4 credit hours

MATH 506 – FOURIER SERIES AND BOUNDARY VALUE PROBLEMS: Partial differential equations of applied science, superposition of solutions, orthogonal sets of functions, Fourier series, boundary value problems for elliptic, parabolic and hyperbolic equations, Bessel functions and applications, Legendre polynomials and applications. An introduction to Green's Function Techniques. Prerequisites: Permission of the Department.
Fall Quarter 4 credit hours

MATH 508 – APPLIED NUMERICAL METHODS: Digital computer-oriented methods for determining roots of equations, solutions of systems of equations, approximation of functions, values of definite integrals, solutions of ordinary and partial differential equations, matrix eigenvalue problems. Prerequisites: None. Winter and Spring Quarters 4 credit hours

MATH 509 – MATHEMATICAL METHODS FOR SPACE OPERATIONS: This course covers basic topics in linear algebra and the calculus of several variables. Topics from linear algebra include matrix algebra, solution of systems of linear equations, real vector spaces, and linear transformations between real vector spaces. Topics from several variable calculus include partial differentiation, directional derivatives, functional transformations and Jacobians, maxima and minima, and integration in two and three variables. Prerequisites: None. Fall Quarter
4 credit hours

MATH 511 – METHODS OF APPLIED MATHEMATICS I: Introductory graduate level course in methods of applied mathematics. Differential and integral calculus of functions of several variables. Vector differential calculus, directional derivatives, gradient, divergence and curl. Line and surface integrals, Green's theorem, divergence theorem and Stokes' theorem. Fourier series expansions. Complex numbers, analytic functions of a complex variable, complex integrals and Cauchy's integral formula. Prerequisites: None.
Fall Quarter 4 credit hours

MATH 513 – METHODS OF APPLIED MATHEMATICS II: Introductory graduate level course in methods of applied mathematics. Complex integrals and Cauchy's integral formula. Orthogonal sets of functions. Laplace transforms and the solution of differential equations. Algebra of matrices, determinants, systems of linear algebraic equations, eigenvalues and eigenvectors, matrix methods for systems of linear differential equations. Power series, Taylor series and Laurent Series. Integration by the method of residues and the evaluation of real integrals. Prerequisites: MATH 511. Winter Quarter 4 credit hours

MATH 521 – APPLIED LINEAR ALGEBRA: Algebra of matrices, the theory of finite-dimensional vector spaces, and basic results concerning eigenvalues and eigenvectors with particular attention to topics that arise in applications. Prerequisites: None. Fall and Spring Quarters
4 credit hours

MATH 600 – MATHEMATICAL ANALYSIS: This course provides the transition from elementary calculus to advanced courses (6XX and above) which require mathematical analysis with rigor. Topics include basic notions of set theory, point set topology, limits and continuity, derivatives, functions of bounded variation, Riemann-Stieltjes Integration, uniform convergence of sequences and series of functions and their consequences thereof and Lebesque measure and integration theory. Prerequisites: None. Fall and Spring Quarters 4 credit hours

MATH 601 – COMPLEX ANALYSIS: : Introduction to the theory of complex variables; analytic functions, elementary functions and their geometry; integrals; power series, residues and poles; conformal mapping; applications. Prerequisites: MATH 600 or MATH 602. Winter Quarter
4 credit hours

MATH 602 – MODERN APPLIED MATHEMATICS I: An introduction to the foundations and applications of modern applied mathematics for second-year graduate students of applied science. Distribution theory and Green's functions applied to one-dimensional boundary value problems. Classical and weak solutions. Alternative theorems. Functions and transformations. Basic properties of linear and metric spaces, including topology, continuity, differentiability, convergence of sequences and series of functions. Banach and Hilbert spaces. Linear functionals. Prerequisites: Permission of the instructor. Fall Quarter
4 credit hours

MATH 604 – MODERN APPLIED MATHEMATICS II: A course in applied functional analysis. Linear operator theory and applications to (approximate) solutions of boundary value problems of applied science. Closed operators, the inverse operator, adjoint and compact operators, and spectrum. Contraction mappings. Applications to Fredholm integral equations arising in science and engineering. Applications of spectral theory of second-order differential operators. Regular and singular problems. The Riemann-Stieltjes integral and spectral resolution. Eigenvalue-eigenfunction approximation. Applications to partial differential equations of applied science. Prerequisites: MATH 602. Winter Quarter 4 credit hours

MATH 605 – NONLINEAR DIFFERENTIAL EQUATIONS: Topics include linear systems with an introduction to phase space analysis, existence theory, stability of linear and almost linear systems. Lyapunov's second method, applications to nonlinear problems and optimal control theory, and an introduction to bifurcation theory and chaos. Prerequisites: MATH 600 or MATH 602. 4 credit hours

MATH 607 – CALCULUS OF VARIATIONS: Topics include a study of functionals, fixed and variable end point problems, canonical forms of the Euler equations and related topics, sufficient conditions for a weak extremum, fields, sufficient conditions for a strong extremum, variational problems involving multiple integrals, direct variational methods, and applications. Prerequisites: MATH 600 or MATH 602. Summer Quarter 4 credit hours

MATH 611 – INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS: Introduction to the fundamental concepts of partial differential equations and applications emphasizing the use of these basic concepts. Topics considered include classification, reduction to canonical form, existence of solutions, variational principles, methods of obtaining solutions of the basic types of equations including both numerical and analytical methods. Prerequisites: MATH 600 or MATH 602. Winter Quarter 4 credit hours

MATH 612 – ASYMPTOTIC AND PERTURBATION ANALYSIS: Topic includes fundamentals of scaling, order symbols, asymptotic sequences and series, matching and generalized expansions. Methods such as strained coordinates, multiple scales, WKB and matched asymptotic expansions are explored with applications to ordinary and partial differential equations. Prerequisites: MATH 602.
4 credit hours

MATH 621 – LINEAR ALGEBRA: Basic algebraic properties of vector spaces and matrices, including dimension and bases, linear transformations, determinants, similarity and congruence, and the solutions of linear systems of equations, generalized inverses, singular value decompositions, Jordan normal form, norms and inner products. Prerequisites: MATH 521. Fall and Spring Quarters 4 credit hours

MATH 631 – ALGEBRAIC STRUCTURES: An introduction to the algebra of semigroups, monoids, groups, rings, integral domains, fields and categories. Emphasis is placed on gaining a fundamental understanding of these basic algebraic structures so that the successful student will be able to apply the material in familiar and unfamiliar settings. Prerequisites: MATH 600 or Permission of the Department.
Spring Quarter 4 credit hours

MATH 633 – GRAPH THEORY: An introduction to the theory and application of graphs. Topics include introductory concepts and definitions, digraphs, connected and disconnected graphs, graph traversals, connection problems, trees, planar and nonplanar graphs, eulerian and hamiltonian graphs, coloring problems, graph isomorphisms, multigraphs. Prerequisites: Permission of the Department.
Spring Quarter 4 credit hours

MATH 674 – NUMERICAL ANALYSIS I: Roots of nonlinear equations, interpolation and approximation of functions, techniques for numerical integration and differentiation, techniques for solving ordinary differential equations, error estimates and convergence analyses for each topic. Prerequisites: MATH 600 or MATH 602, and MATH 521. Spring Quarter 4 credit hours

MATH 676 – NUMERICAL ANALYSIS II: Special techniques for solution of large systems of linear algebraic equations, generalized inverses, numerical treatment of matrix eigenvalue problems. Consistency, convergence and stability of schemes for solution of ordinary and partial differential equations. Prerequisites: MATH 674. Summer Quarter
4 credit hours

MATH 678 – FINITE ELEMENT TECHNIQUES IN APPLIED SCIENCE: Solutions of elliptic, parabolic, and hyperbolic partial differential equations using finite element techniques and solutions of eigenvalue problems are treated. Error estimates and applications are considered. Prerequisites: MATH 676 and MATH 607.
4 credit hours

MATH 705 – LINEAR FUNCTIONAL ANALYSIS: Introduction to metric space and normed linear spaces, operators and functionals on a Banach space, dual space; concrete representations and applications in Hilbert space, Hahn-Banach theorem, Open Mapping theorem, Banach-Steinhaus theorem, Closed Graph theorem, and topics in spectral theory. Prerequisites: MATH 621 and MATH 600. 4 credit hours

MATH 799 – INDEPENDENT STUDY: Thesis research. Prerequisites: Permission of the department.
1-12 credit hours

MATH 831 – MATHEMATICAL OPTIMIZATION AND CONTROL: Modern Banach space formulation of optimization and control problems; evolution equations and semigroup theory. Calculus in Banach spaces; Bochner integral, Gateaux and Frechet derivatives; optimization of functions. The geometric approach to optimal estimation in a Hilbert space; topics in linear system theory. Geometric approach to the global and local theory of constrained optimization in a Banach space. Iterative methods of optimization. Prerequisites: MATH 705. 4 credit hours

MATH 874 – FUNCTIONAL ANALYSIS AND NUMERICAL ANALYSIS: Stability, consistency and convergence of difference schemes for well-posed pure initial value problems. Applications of fixed point theorems; function-analytic versions of Newton's method and of regula falsi. Finite element methods from the perspective of function-analytic optimization. Prerequisites: MATH 705. 4 credit hours

MATH 999 – DISSERTATION RESEARCH: Prerequisites: Approval of Research Advisor. 1-12 credit hours

STATISTICS

STAT 525 – APPLIED STATISTICS FOR MANAGERS I: Major subject areas in this first course in statistics include descriptive statistics, probability theory and statistical inference. This course is tailored to provide the future military logistician with these essential tools in a framework to which he/she can relate. Prerequisites: None. Fall Quarter 4 credit hours

STAT 526 – APPLIED STATISTICS I: This is the first course in the fundamentals of managerial statistics. The probability theory necessary to provide a foundation for statistics is developed. Topics include Bayes theorem, discrete and continuous random variables, cumulative distribution functions, joint probability distributions, expectation and functions of random variables, measures of central tendency and variation, sampling and sampling distributions, the Central Limit Theorem, and point/interval estimation. Prerequisites: None. Fall and Spring Quarters 4 credit hours

STAT 527 – INTRODUCTION TO PROBABILITY: This course presents the basic concepts of probability. Emphasized topics are basic probability, discrete and continuous random variables, joint probability distributions and expectation. Prerequisites: None.
4 credit hours

STAT 535 – APPLIED STATISTICS FOR MANAGERS II: Statistical methods needed to gather, interpret and apply data in the decision making process are presented. Concepts discussed include methods on how to: specify what data is wanted, collect data extract information from existing sources of data, test the validity of key concepts, make intelligent estimates of major problem parameters, and relate one decision variable to another. Prerequisites: STAT 525. Winter Quarter
3 credit hours

STAT 536 – APPLIED STATISTICS II: This is a second course in statistics stressing the point of view that statistics provides the tools for making decisions under conditions of uncertainty. Emphasis is on the processes by which the data are used to make decisions about the population of which the data are a part. Subjects include tests of hypotheses, regression, linear hypotheses and analysis of variance. Prerequisites: STAT 526. Winter and Summer Quarters 3 credit hours

STAT 537 – INTRODUCTION TO STATISTICS: This course presents the basic concepts of statistics. Emphasized topics are sampling theory, estimation, hypothesis testing, regression and, nonparametric statistics. Prerequisites: STAT 527. Winter Quarter
4 credit hours

STAT 583 – PROBABILITY AND STATISTICS FOR COMPUTER SCIENCE: Basic concepts of probability and statistics with computer science applications are covered. Topics include: Permutations and combinations; random variables; probability distributions; estimation and confidence intervals; hypothesis testing. Prerequisites: None. Fall Quarter 4 credit hours

STAT 586 – PROBABILITY THEORY FOR COMMUNICATION AND CONTROL: Selected topics from probability theory are introduced as a basis for applications in the analysis and design of modern communication and control systems. Topics include the concepts of sample space, random variables, random vectors, probability densities, probability distributions, discrete and continuous distributions, expectation and moments, characteristic functions, transformations of random variables and vectors, multivariate normal distribution. Prerequisites: None.
Fall Quarter 4 credit hours

STAT 601 – THEORY OF PROBABILITY: Topics include random variables, binomial, hypergeometric, Poisson, exponential gamma, normal, moment-generating functions, joint distribution of functions of several random variables, conditional expectation and conditional density functions, Limit theorems. Prerequisites: None.
Winter Quarter 4 credit hours

STAT 602 – MATHEMATICAL STATISTICS: This course provides the student with a solid foundation in the basic concepts of mathematical statistics. Topics include tests of hypotheses, point and interval estimation, sufficient statistics, UMVV estimates, Cramer-Rao Inequality, simple multiple regression. Prerequisites: STAT 601. Fall Quarter 4 credit hours

STAT 687 – Mathematics of Reliability Theory I: Reliability models, reliability estimation, exponential and Weibull models, sequential life testing, Bayesian reliability in testing and design, goodness-of-fit tests, accelerated testing reliability growth models. Prerequisites: STAT 602.
4 credit hours

STAT 694 – Design of Experiments: This course gives an introduction to the linear statistical model and its associated forms of inference with special emphasis on analysis of variance models. The classical experimental design models are analyzed with emphasis on fractional factorial designs and their application to engineering problems. The student will be able to pose a research question in statistical terms and design an experiment to answer that question including determination of EMS and F-tests. Prerequisites: STAT 537 or STAT 602. Summer Quarter
4 credit hours

STAT 696 – Applied General Linear Models: Theory and application of the general linear statistical model. Population distribution and/or parameters are tested using regression and analysis of variance in the context of the general linear model. Topics covered include general regression and correlation analysis, basic analysis of variance, and multifactor analysis of variance. Prerequisites: STAT 527, STAT 537, or STAT 602. Spring Quarter
4 credit hours

STAT 697 – Mathematics of Reliability Theory II: Goodness-of-fit tests, accelerated testing, Monte Carlo and distribution free methods, accelerated life testing, reliability design, stress strength models, reliability growth models, and reliability optimization. Robust techniques will be stressed. Review of reliability measures, static reliability models, dynamic reliability models, probabilistic engineering design, inference theory reliability design, time dependent stress strength models, combinations of random variables in design. Prerequisites: STAT 687.
4 credit hours

STAT 737 – Introduction to Multivariate Analysis: Graduate level course in mathematics of multivariate analysis. Properties of multivariate normal distribution, estimation of the mean vector and the covariance matrix, multivariate sampling theory and multivariate analysis of variance. Prerequisites: MATH 521, STAT 602 and STAT 696.
4 credit hours

STAT 799 – Independent Study: Thesis research. Prerequisites: None.
1-12 credit hours

STAT 999 – Dissertation Research: Prerequisites: Approval of Research Advisor.
1-12 credit hours

Department of Operational Sciences

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Introduction

The Department of Operational Sciences is home to the graduate programs in Operations Research (OR), Logistics Management, and Mobility Management. An interdisciplinary department, its faculty holds a broad range of expertise in the fields of modeling and simulation, decision analysis, information operations, inventory management, transportation management, logistics management, and strategic mobility.

Faculty

Professors

Kenneth W. Bauer, Jr. (simulation, pattern recognition)

William A. Cunningham III (transportation, strategic mobility)

Richard F. Deckro (math programming, information operations, scheduling, project management)

Associate Professors

James W. Chrissis, PE (math programming, stochastic systems, simulation)

Raymond R. Hill, Jr. (heuristics, optimization, simulation)

James T. Moore (integer programming, heuristics)

Assistant Professors

John M. Andrew (training simulations, stochastic systems)

Stephan P. Brady (strategic mobility, transportation)

Stephen P. Chambal (decision analysis, simulation)

Stanley E. Griffis (logistics management)

Jeffrey P. Kharoufeh (stochastic systems)

Paul W. McAree (statistical analysis, linear/integer programming)

J. O. Miller (simulation, ranking, and selection)

William P. Nanry USA (optimization, heuristics, combat modeling)

Stephen M. Swartz (production management)

Victor D. Wiley (metaheuristics)

Programs of Study

Operations Research (GOR)

The purpose of the program is to educate students in the theory and practice of operations research with emphasis on the application of quantitative analysis techniques to defense decision-making. Specific topics of study include mathematical combat modeling, simulation, statistical analysis, and optimization. Applicants for the Graduate Operations Research program should hold a baccalaureate degree in engineering, science, mathematics, or other quantitative discipline.

All GOR students must develop a foundation in fundamental operations research methods and associated disciplines. This objective is accomplished through satisfaction of the following core course and mathematics requirements:

Probabilistic Operations Research (OPER 540)
Discrete Event Simulation (OPER 561)
Linear Programming (OPER 610)
Mathematics (MATH 501, MATH 502)
Statistics (STAT 537, STAT 696)

Students who have previously taken comparable graduate courses may request transfer credit or waiver of specific courses through their faculty advisor. Under appropriate circumstances, the Head of the Department of Operational Sciences may approve course substitutions.

In addition to the core requirements, students select an area of specialization. The areas of specialization are:

DETERMINISTIC OR: Introduces the student to various areas in the field including optimization, linear, nonlinear and integer programming, graph theory, multicriteria decision making, heuristic search methods, scheduling theory, and project management.

PROBABILISTIC OR: Covers the subjects of decision analysis, stochastic processes, queuing systems, and reliability theory.

SIMULATION: Prepares students in the subjects of simulation modeling and analysis, response surface methodology, and multivariate data analysis.

APPLIED STATISTICS: Covers the subjects of statistical process control, response surface methodology, forecasting, design of experiments, and multivariate analysis.

INFORMATION OPERATIONS/INFORMATION WARFARE: Covers the subjects of information warfare, combat modeling, and information operations.

OPERATIONAL MODELING: Covers the subjects of weapon effects, combat modeling, and mobility modeling.

Logistics Management (GLM)

The purpose of the program is to develop logistics managers who can efficiently utilize scarce resources and effectively coordinate and direct a myriad of functional areas necessary to achieve the agile combat support mission. Applicants for the Graduate Logistics Management program may submit Graduate Management Admissions Test (GMAT) scores of at least 550 in place of the Graduate Record Examination (GRE) and have completed mathematics courses through college algebra with a grade of C or higher.

Each student who graduates with a Master of Science in Logistics Management must have a foundation in the theoretical and applied aspects of business, as specified by the International Association for Management Education (AACSB). The following courses are prerequisites for the degree, and students identified with a deficiency are expected to fulfill this requirement by taking the appropriate courses:

Organization & Management Theory (ORSC 542)
Managerial Economics (AMGT 520)
Managerial Statistics I (STAT 526)
Managerial Statistics II (STAT 536)

All GLM students must develop a foundation in fundamental management and quantitative logistics methods and research methods. This objective is accomplished through the following core course requirements:

Activity Based Costing/Management (LOGM 620)
Contracting and Acquisition Management (CMGT 523)
Management Information Systems (IMGT 523)
Quantitative Decision Making (OPER 501)
Computer Simulation for Managers (LOGM 590)
Research Methods (RSCH 630)
Supply Chain Management (LOGM 627)

Students who have previously taken comparable graduate courses may request transfer credit or waiver of specific courses through their faculty advisor. Under appropriate circumstances, the Head of the Department of Operational Sciences may approve course substitutions.

In addition to the core courses, students select an area of specialization. The areas of specialization with typical a typical course selection include acquisition logistics (LOGM 614, SMGT 643, SMGT 646), logistics management (LOGM 569, LOGM 636, LOGM 638), inventory management (LOGM 629, LOGM 628, LOGM 630), and transportation management (LOGM 617, LOGM 618, LOGM 619).

Mobility Management (GMO)

The GMO program is the formal graduate degree component of the Advanced Study in Air Mobility (ASAM) executive development program sponsored by the Air Mobility Command's Air Mobility Warfare Center (AMWC) at Fort Dix, New Jersey. The goal of the ASAM program is to cultivate a core of future mobility leaders with an in-depth education in air mobility operations.

Typical students in the ASAM program are rated or support officers with nine to thirteen years commissioned time in service (i.e., senior captains or junior majors) and have experience in mobility operations. Rated officers must be qualified in their assigned weapons systems. All applicants must possess or be eligible to obtain a Top Secret (TS-SSBI) clearance. Applicants for this program may also submit Graduate Management Admissions Test (GMAT) scores of at least 550 in place of the Graduate Record Examination (GRE) and must have completed mathematics courses through college algebra with a grade of C or higher.

Employing a "whole person" concept, a central board chaired by the Air Mobility Command Vice Commander selects only the best officers for this rigorous program. All applicants must be proven leaders worthy of future consideration for command.

The curriculum consists of the following 13 required courses in the areas of transportation, logistics, contracting, quantitative decision-making, statistics, management, maintenance, and production. Courses are taught individually in a compressed schedule, typically two weeks in length. The program also requires a graduate research paper that examines a topic pertaining to mobility operations. Because of the unique nature of this program, course substitutions, waivers, and so forth are not allowed.

- CMGT 523 – Contracting and Acquisition Management
- ORSC 542 – Organization and Management Theory
- OPER 501 – Quantitative Decision Making
- OPER 674 – Joint Mobility Modeling
- RSCH 630 – Research Methods
- LOGM 525 – Statistics for Mobility Managers
- LOGM 557 – Seminar in International Aerospace Studies
- LOGM 568 – Logistics Management
- LOGM 569 – Maintenance and Production Management
- LOGM 617 – Transportation Systems and Strategic Mobility
- LOGM 619 – Transportation Policy
- LOGM 627 – Supply Chain Management
- LOGM 634 – Reliability, Maintainability, and Quality Management
- LOGM 791 – Research Project for Mobility Managers

Doctor of Philosophy (Ph.D.) Program

The Department of Operations Research offers studies leading to the award of a Ph.D. with a concentration of operations research. The Doctor of Philosophy degree is considered the pinnacle of academic achievement. Unlike other graduate degrees, the Ph.D. is a research degree, and it represents mastery of a specialized field and demonstrated ability to do independent research leading to a significant and original contribution to the body of knowledge. A person upon whom the department's Ph.D. has been conferred is considered an expert in their research specialty with broad competency in the key areas of OR and mathematics.

Areas available for concentrated study include deterministic methods, probabilistic methods, simulation, and applied statistics

The department core requirement is designed to provide broad exposure to the key areas of OR at a level commensurate with Ph.D. study, and consists of the following (or their equivalents):

- Nonlinear Programming (OPER 612)
- Applied Stochastic Processes (OPER 641)
- Simulation Modeling and Analysis (OPER 660)
- Response Surface Methodology (OPER 683)

Each student must satisfy this requirement, either through these courses explicitly or by appropriate courses taken at other institutions (subject to department approval).

Department Facilities

The Center for Modeling, Simulation, and Analysis (CMSA) provides an environment designed to encourage and enhance exceptional faculty/student research that addresses current AF/DoD problems. The CMSA facilities provide a number of computer workstations along with PCs and specialized software to explore, extend, and apply legacy and emergent modeling and simulation methods. In addition, the CMSA provides support to the Air Force analytical community through the Air Force Standard Analysis Toolkit (AFSAT).The AFSAT consists of over 20 computer simulation/ analysis models that run on a variety of computer platforms. A significant number of these models are used in direct support of combat modeling courses and sponsored research. Since 1993, the CMSA has supported over $2.5 million dollars in research efforts for projects with Air Force, DoD and other federal agencies, and private companies under cooperative research agreements.

Department Research

The Department of Operational Sciences is home to an interdisciplinary faculty with the following research focus:

- Apply state-of-the-art mathematical and computing technologies to the solution of customer-focused operational problems
- Support better planning and decision-making in complex operational systems
- Realize AF vision of agile combat support through more efficient and effective use of logistics resources
- Enhance the Air Force’s joint warfighting capabilities

Areas of recent interest include campaign planning and execution, decision and risk analysis, information operations/information warfare, operational modeling and simulation, operational problems and heuristic modeling, statistical analysis, and transportation and strategic mobility.

Course Offerings

LOGISTICS MANAGEMENT

LOGM 525 – STATISTICS FOR MOBILITY MANAGERS: This course is designed to provide students who do not have a knowledge of statistics with a fundamental understanding of the principles. The topics to be covered in this course are aimed at developing an understanding of how to collect and analyze data including descriptive statistics; probability theory and probability distributions; sampling and inferential statistics; regression analysis and analysis of variance; and some non-parametric statistics. The coverage of the topics will be at an adequate depth to provide the level of understanding needed by managers to effectively conduct business. Prerequisites: None.
4 credit hours

LOGM 557 – SEMINAR IN INTERNATIONAL AEROSPACE STUDIES: The purpose of this course is to examine the structure of the aerospace industry and the forces which are pushing it toward international collaboration. The benefits, drawbacks, and characteristics of international cooperative ventures are examined. In addition, the history of American military efforts at armament cooperation is presented, with emphasis on the political, military, and economic issues surrounding co-production and co-development programs. Prerequisites: None. Winter Quarter 3 credit hours

LOGM 566 – OPERATIONS MANAGEMENT FOR ENGINEERING AND ENVIRONMENTAL SYSTEMS: The course is designed to be a survey course in a variety of Operations Management techniques, such as forecasting, capacity planning, facility layout, inventory management, scheduling, project management, and operations costing. The role of operations in complex systems that resemble "maintenance of physical plant and real property" and "provision of engineering services" environments provides the context for decision making. Classical business models are tailored to the unique DoD and USAF requirements. Prerequisites: None. Summer Quarter
3 credit hours

LOGM 568 – LOGISTICS MANAGEMENT: This course examines physical distribution theory, concepts, and practices as applied in both commercial and DoD organizations. Elements of the physical distribution system (e.g., inventory, warehousing, materials handling, packaging, and transportation) are considered singly and interactively. Emphasis is on linkages that must be recognized in the design and management of physical distribution systems. The commercial and DoD environments are compared and contrasted; and, physical distribution issues impacting strategic mobility are analyzed. Prerequisites: None. Winter Quarter
3 credit hours

LOGM 569 – MAINTENANCE AND PRODUCTION MANAGEMENT: This course explores operations management functions as applied to an Air Force environment. The course familiarizes the student with a variety of operations management techniques which are being applied in maintenance as well as a variety of other operations management settings. Course topics include productivity, facility layout, location, capacity planning, quality control +TQM, forecasting, and current operations management innovations. Prerequisites: None. Spring Quarter 3 credit hours

LOGM 590 – COMPUTER SIMULATION FOR MANAGERS: The course concentrates on the concept of designing a model, running experiments with that model, and analyzing the results. The course's main emphasis is on the proper use of simulation techniques to model systems and answer logistics questions. Course work focuses on the use of the computer to enhance the decision-making capabilities of the logistics manager. This course provides the student with a working knowledge of discrete-event computer simulation as a decision-making tool. Prerequisites: None. Winter Quarter 4 credit hours

LOGM 609 – QUALITY MANAGEMENT AND CONTROL: The quality of the components of military systems is a primary determinant of military capability. The need to manage quality control programs is becoming increasingly apparent. The effect on systems effectiveness of quality improvement programs has been dramatically demonstrated in recent years by the Japanese applications of sound basic management practices. This course applies basic statistical and management concepts to permit in-depth study of the theory and realities of implementing quality control. Prerequisites: MATH 525, MATH 535 or equivalents. 3 credit hours

LOGM 614 – ACQUISITION LOGISTICS OVERVIEW: This course introduces each student to the need to consider support requirements early in the system life cycle. The concept of designing for support is explored in detail. The elements of logistics are examined as entities in themselves and as part of a greater system. Operation and support costs are reviewed in light of the system life cycle. Additional areas of interest include the impact of acquisition reform and integrated weapon system management. Prerequisites: None. Spring Quarter 3 credit hours

LOGM 617 – TRANSPORTATION SYSTEMS AND STRATEGIC MOBILITY: Examines each transportation mode for similarities and differences. Ownership of the modes is also detailed, along with cost and service characteristics. Each mode is then examined for its particular contribution to the defense transportation system. The mission, organization, resources and financing arrangements of the three transportation operation agencies of the defense transportation system are examined. Problems associated with strategic mobility are emphasized. Prerequisites: AMGT 520. Spring Quarter 3 credit hours

LOGM 618 – TRANSPORTATION MANAGEMENT: Considers transportation from a managerial perspective. Examines decision-making in the transportation organization, to include methods and techniques for evaluating alternate courses of action available to meet fiscal, service and/or other management objectives. Ways of measuring cost, qualitative factors and effectiveness of transportation service are presented. Case studies are used extensively to provide the student with practical experience in applying the skills discussed. Prerequisites: LOGM 617. Summer Quarter 3 credit hours

LOGM 619 – Transportation Policies: Focuses on a study of the complex national and defense transportation policy frameworks that guide the constant development of our transportation systems. Examines how transportation policy impacts, and is, in turn, impacted by policies formulated to address other national issues. Particular emphasis is placed on the study of the effects of national policies on the defense transportation system. Policy analysis models are presented and discussed. Prerequisites: None. Fall Quarter 3 credit hours

LOGM 620 – Activity Based Costing/Management: The course is designed to give the students a working knowledge of Activity Based Costing (ABC), including what it is, why traditional accounting practices do not support managerial decision-making, and techniques to perform ABC. The necessity of accurate costing will be emphasized, with examples from current privatization initiatives within DoD, as well as commercial sector cases. Once the student is familiar with cost allocation under ABC, Activity Based Management (ABM) will be introduced to enable the student to utilize the output from ABC. In addition, the development and application of non-financial metrics, essential in ABM, will be covered. Prerequisites: None. Summer Quarter 3 credit hours

LOGM 627 – Supply Chain Management: Intended as a capstone course for professional logisticians, LOGM 627 develops the major themes and strategies of Supply Chain Management. The focus is on the system design, structure, capacity and management of an integrated supply chain. Subject matter includes cross functional analysis and treatment of sourcing/supply, distribution/transportation, maintenance/operations and related logistics support issues in a system-wide approach. Main themes developed are the necessity of an integrative approach to strategy, policy, and decision making; and the need to emphasize system commonality of sourcing distribution and operations to form an integrated supply chain in support of global military operations. Prerequisites: LOGM 569, LOGM 628, LOGM 617. Winter Quarter 3 credit hours

LOGM 628 – Reparable Inventory Management: This course is a survey of contemporary theory and practice in the area of reparable item inventory management. The focus of the course content is on the military reparable item logistics pipeline system, with specific emphasis given to the effects of inventory policy and decision-making on logistics costs and weapon system availability/sustainability. The course material is essentially modeling and operations research oriented; however, course emphasis is on understanding and applying the algorithms presented, rather than on theorems or proofs. Coverage includes state-of-the-art inventory thinking for a variety of inventory management problems, such as: single versus multiple stockage locations, single versus multi-item optimization, cannibalization versus no cannibalization policies, peacetime versus wartime demand rates, and a variety of other scenarios. Specific model coverage includes METRIC, Mod-METRIC, Aircraft Availability Model, Vari-METRIC, and Dyna-METRIC. Prerequisites: STAT 525, LOGM 629. Summer Quarter 3 credit hours

LOGM 629 – Consumable Inventory Management: This course is a survey of contemporary theory and practice in the area of consumable item inventory management. The course content focuses on the management of service parts inventories for military logistics systems, emphasizing the effects that inventory policy and decision-making have on logistics costs and selected

performance measures. The course blends practitioner-based and operations research-based perspectives; however, course emphasis is on understanding and applying key inventory management concepts, rather than on theorems or proofs. The course material includes: managing inventories under certainty and uncertainty, inventory performance measurement, single versus multiple stockage location alternatives, information systems, physical item inventory accuracy, and warehousing design and operation. Prerequisites: STAT 525.
Spring Quarter 3 credit hours

LOGM 630 – Forecasting Management: Since the DoD community collects much of its data as a natural time series, this course is concerned with the application of time series analysis theory in describing and forecasting logistics performance. This course covers analysis of time series data patterns, introduction of major forecasting techniques, measuring the effectiveness of these techniques, and implementing time series analysis theory in describing and forecasting logistics performance. Statistical developments will be brief with an intent to survey a wide variety of concepts. Forecasting methods covered include: moving average; exponential smoothing; regression; econometric; and Box-Jenkins. Prerequisites: STAT 525.
Fall Quarter 3 credit hours

LOGM 634 – Reliability, Maintainability, and Supportability: The first part of the course will address reliability and maintainability (R&M) issues. This part of the course teaches fundamental R&M concepts, including R&M measures, component availability and R&M prediction. Additionally, probability theory is discussed and employed as a tool to quantitatively define these concepts. The second part of the course will address quality issues from a management perspective. The application of proven and innovative techniques with a quality focus for the management and control of programs in the defense environment is well documented. This course builds upon and applies basic statistical and systems management concepts. The materials for both parts of the course are presented in a lecture/discussion format with dialogue encouraged on the issues. Prerequisites: STAT 525, STAT 535 or equivalents. 3 credit hours

LOGM 636 – Service Operations Management: The body of knowledge pertaining to the management of operations has evolved largely in the context of manufacturing. However, the majority of operations in both the commercial and defense sectors are more properly classified as services, whose outputs are less tangible. This course draws on production management techniques to enhance the effectiveness of managers of service operations. Topics covered include characteristics of services, establishing customer service levels, designing service delivery systems, measuring system performance, the psychology of waiting lines, and scheduling personnel and capacity. Prerequisites: QMGT 675 or approval of course director. Summer Quarter 3 credit hours

LOGM 637 – Theory of Constraints: This course presents the concepts of the Theory of Constraints as they relate to both commercial and military enterprises. The course addresses: 1) what to change, 2) what to change to, and 3) how to make the change. Extensive use of effect-cause-effect analysis as well as other creative problem solving techniques are included in the course. Computer simulations are used to illustrate many of the course concepts. Prerequisites: LOGM 569 or approval of Instructor. Fall Quarter
3 credit hours

LOGM 644 – Current and Emerging Topics in Logistics: This course is presently structured around three blocks of material – Just-in-Time (JIT) practices, environmental logistics, and space logistics. Adoption of JIT practices represents the primary thrust of AFMC's Lean Logistics Initiative. The JIT block of the course will familiarize students with JIT production management research and will emphasize its implications for DoD distribution and production/repair environments. Each student will be required to critique one journal article and present their critique of the research to the class. In the past decade environmental considerations have become a major factor in the acquisition and logistical support of weapon systems. The environmental logistics block will address DoD and Air Force pollution prevention policy and the application of source reduction, substitution, recycling, and hazardous materials disposal to the logistics functions of purchasing, transportation, warehousing and storage, packaging, and maintenance. Students will be required to conduct an environmental audit of a selected logistics function in a DoD organization and to compile their findings in a short report. The third block of the course will concentrate on the application of logistics principles to the primary space systems segments of launch, space, and control. Space systems are transitioning to constellations of spacecraft with reusable launch systems and more cost-effective control networks. In a cost-constrained environment, life cycle cost reductions through standardization and normalization of support processes are essential. The space logistics block will relate the ILS elements to space systems, will examine the composition of and critical support requirements for launch vehicles, space vehicles, and control centers, and will look at the current maintenance problems and maintenance theories. Each student will be required to analyze a case study concerning the logistics support of launch vehicles or a space station or to perform a cost analysis of support options for a control center. Prerequisites: LOGM 568, LOGM 569, LOGM 590. Fall Quarter 3 credit hours

LOGM 675 – Logistics Management Colloquium: This course introduces students to current issues, concerns, and practices of logistics management through a series of presentations by key logistics personnel during the 15-month graduate program. Prerequisites: None. Offered All Quarters
0 credit hours

LOGM 791 – Research Project for Mobility Managers: A research topic is selected from mobility problems of interest to USAF and DoD. This topic is thoroughly investigated by the student, and the findings, recommendations, and conclusions are presented as a graduate research paper under the supervision of an AFIT faculty member. Prerequisites: None.
7 credit hours

OPERATIONS SCIENCE

OPER 498 – Research Methods: This course is designed to provide the student with an understanding of the research process and department research expectations. Topics include problem definition, use of secondary sources, research design and communication of results. Students prepare and present a research proposal. Prerequisites: None. Spring Quarter
1 credit hour

OPER 500 – Operational Sciences Seminar: This seminar acquaints students with the application of operations research to Air Force and DoD issues and with faculty research interests. This course also provides a forum for lectures by distinguished visitors. Prerequisites: None. Fall, Winter, and Spring Quarters 0.5 credit hour

OPER 501 – QUANTITATIVE DECISION MAKING: This is an introductory course in management science applications for the logistics, systems, acquisition and transportation manager. Emphasis is on understanding and applying the techniques to managerial problem solving and decision making. Major topics include linear programming, decision theory, networks, and queuing theory. Prerequisites: None. Fall and Winter Quarters 3 credit hours

OPER 510 – DETERMINISTIC OPERATION RESEARCH: This course develops basic optimization theory, building on mathematical fundamentals introduced in the calculus. The emphasis of this course is on exposure to deterministic methods at an introductory graduate level. Topics include fundamentals of linear programming, integer programming, nonlinear programming, and dynamic programming. The emphasis is on problem solving and examples. Prerequisites: None. Corequisite: MATH 502.
4 credit hours

OPER 531 – ECONOMIC ANALYSIS I: In this course, the theory of choice is discussed and illustrated by the theory of consumer behavior. Its relationship to cost-effectiveness analysis is discussed. The Sludsky equation is derived and a cost-effectiveness problem is developed which utilizes the concept. Demand equations are derived and utilized to test the sensitivity of a cost-effectiveness problem. Production functions are introduced and discussed. Prerequisites: MATH 501.
3 credit hours

OPER 540 – PROBABILISTIC OPERATIONS RESEARCH: This course builds on fundamental probability theory to develop some of the better known approaches to stochastic modeling in operations research. Specific modeling topics include discrete and continuous-time Markov processes, the Poisson process, queuing theory, and reliability. The strengths and weaknesses of various stochastic models are discussed in the context of military applications. Prerequisites: OPER 510, STAT 527. Winter Quarter
4 credit hours

OPER 543 – DECISION ANALYSIS: This course is decision analysis theory and methodology. Decision analysis applies to hard problems involving sequential decisions, major uncertainties, significant outcomes, and complex values. The course includes: decision structuring with influence diagrams and decision trees; modeling uncertainty with subjective probabilities; sensitivity analysis and the value of information; and modeling preferences with utility functions. Decision analysis applications for USAF and DoD problems are considered. Prerequisites: STAT 527. Winter and Spring Quarters
3 credit hours

OPER 560 – MILITARY SYSTEMS SIMULATION: This is an introductory course on the use of computer simulation modeling to analyze complex military systems. The focus of the course is on the development of simulation models and the analysis of simulation model input and output. A simulation language is taught to provide a modeling framework and the means for implementing a computerized model. Basic concepts important to simulation studies such as random number and random variate generation, model verification and validation, and output analysis are discussed. Examples and applications are oriented toward both operational and support systems within the DoD. Prerequisites: STAT 537. 4 credit hours

OPER 561 – DISCRETE-EVENT SIMULATION: This is an introductory course on the use of computer simulation modeling to analyze complex military systems. The focus of the course is on the development of discrete-event simulation models and the analysis of simulation model input and output. A modern simulation language is taught to provide a modeling framework and the means for implementing a computerized model. Basic concepts important to simulation studies such as random number and random variate generation, model verification and validation, and output analysis are discussed. Examples and applications are oriented toward operational systems within the DoD. Prerequisites: STAT 537. Spring Quarter 4 credit hours

OPER 595 – ISSUES IN DEFENSE ANALYSIS: This course discusses the role of analysis in defense decisions and examines the historical contributions and limitations of analysis in the decision-making process. Specific topics include the origins of defense analysis, measures of merit, modeling, analytical pitfalls, contemporary topics, and issues of bias, advocacy, and ethics in defense analysis. Prerequisites: OPER 510, OPER 540, OPER 560. Winter Quarter 3 credit hours

OPER 601 – OPERATIONS RESEARCH SEMINAR: This course is designed to provide students, primarily those enrolled in the doctoral program with information relating to the state-of-the-art within the Operations Research field. Prominent speakers in the field will be invited and used whenever possible. This course may also be used by the faculty to present recent developments in their research and by doctoral candidates to present progress reports on their dissertation research. Prerequisites: None. Offered All Quarters 0 credit hours

OPER 610 – LINEAR PROGRAMMING AND NETWORK FLOWS: This course is an in-depth view of linear programming (LP) and network-flow problems. It includes model formulation, theoretical constructs, solution algorithms (simplex and interior-point methods), postoptimality analysis, and large-scale considerations. Related areas, such as specialized LP, network models and first-order approximations are presented. Software systems and models used to solve DoD problems are discussed. Prerequisites: OPER 510. Spring Quarter 4 credit hours

OPER 612 – NONLINEAR PROGRAMMING: This course is a detailed study of applied nonlinear programming techniques. The differential calculus and Karush-Kuhn-Tucker results for constrained optimization are presented, including convexity, local and global optima, and saddle point conditions. Techniques for solving nonlinear programs are presented. Geometric programming, including signomial programming, is covered, along with applications. Students gain experience with nonlinear programming through applications to real-world problems. Prerequisites: OPER 610. Summer Quarter 3 credit hours

OPER 613 – INTEGER PROGRAMMING: Integer programming is the class of mathematical programming models that requires some or all of the variables to assume discrete or integer values. This courses covers modeling, theoretical developments, and the principal solution procedures associated with the subject. At the completion of the course, the student should be able to recognize when integer programming is appropriate, set up a model for solution by an available algorithm, solve the model, interpret the solution, and understand the theoretical basis for the solution procedure. Prerequisites: OPER 610. Summer Quarter 3 credit hours

OPER 615 – LARGE SCALE SYSTEMS OPTIMIZATION: Large scale systems optimization takes advantage of the structure of large problems to develop efficient algorithms for their solution. Many large problems can only be solved by taking advantage of these special structures. The course examines the relationship between special structures and the algorithms which take advantage of them. Topics include interior point methods, Dantzig-Wolfe decomposition, column generation, Bender's decomposition, generalized upper bounding, and Lagrangian relaxation. Several examples of large problems will be examined, including scheduling a delivery fleet. Prerequisites: OPER 610. Winter Quarter
3 credit hours

OPER 616 – GRAPH THEORY: An introduction to the theory and application of graphs. Topics include introductory concepts and definitions, digraphs, connected and disconnected graphs, graph traversals, connection problems, trees, planar and nonplanar graphs, eulerian and hamiltonian graphs, coloring problems, graph isomorphisms, and multigraphs. Applications of graph theory to problems in network flows and in combinatorial optimization are described. Prerequisites: Consent of Instructor. 4 credit hours

OPER 617 – NETWORKS AND COMBINATORIAL OPTIMIZATION: This course is an in-depth study of combinatorial programming and network flow optimization. The emphasis will be placed on discrete optimization and specialized solution techniques which are efficient ways to solve mixed-integer programming problems. These techniques include minimum cost flow, networks with gains, multi-commodity flow networks, networks with side constraints, and Lagrangian relaxation. Computational complexity is also discussed. Prerequisites: OPER 610. Fall Quarter 3 credit hours

OPER 623 – HEURISTIC SEARCH METHODS: Introduction and application of modern search methods for solving complex optimization problems. Topics include genetic algorithms, simulated annealing, tabu search, hybrid combinations, and adaptive techniques. Prerequisites: OPER 613. Fall Quarter
3 credit hours

OPER 626 – SCHEDULING THEORY: This course will cover the fundamentals of sequencing and scheduling. It will concentrate on the terminology, measures of effectiveness and basic problems found in the literature. Specific applications in vehicle scheduling will be introduced. Prerequisites: OPER 510. Summer Quarter 3 credit hours

OPER 628 – ANALYSIS OF ALGORITHMS WITH OR APPLICATIONS: This course is an introduction to the analysis of the computational complexity of algorithms. It will cover basic counting techniques, O(*) notation, and NP-Completeness. General algorithms will be studied in the areas of sorting and graph theory. Classic approaches to such problems as the traveling salesman problem and scheduling will also be covered. Prerequisites: OPER 610. Winter Quarter 3 credit hours

OPER 631 – ECONOMIC ANALYSIS II: The estimation of various types of production functions is undertaken as a means of deriving Effectiveness Curves. A complete theoretical devel opment of least cost production is undertaken. The role of time value of money is developed and is used to develop the cost constraints associated with effectiveness curves. A life cycle cost model is developed and is used to analyze a military weapons system procurement model. Linear systems are investigated. Prerequisites: OPER 531. 3 credit hours

OPER 632 – COST ANALYSIS FOR SYSTEMS DESIGN: This course covers the principles of engineering economy, the development of cost estimating relationships, and the employment of the life cycle concept. Attention is paid to the measurement of tangible and intangible benefits. The goal of the course is to provide a complete treatment of cost analysis, originating with the identification of a need and ending with phase-out and disposal. Prerequisites: STAT 527. 3 credit hours

OPER 635 – LIFE CYCLE COST AND ECONOMIC ANALYSIS: This course covers the theoretical development of life cycle costing and the use of the concept in developing a cost/effectiveness analysis of proposed competing systems. At the end of the course, the student should be able to perform a reasonable cost/effectiveness evaluation of several competing systems. Prerequisites: STAT 527.
4 credit hours

OPER 641 – APPLIED STOCHASTIC PROCESSES: This course develops some advanced concepts in stochastic modeling which extend beyond the boundaries of Markovian systems. Specific topics include generalizations of the Poisson process, renewal theory, semi-Markov processes, time reversibility, Brownian motion, and random walk processes. Techniques for approximate analysis of complex stochastic models are also introduced. Prerequisites: OPER 540. Summer Quarter 3 credit hours

OPER 643 – ADVANCED DECISION MAKING: This course presents advanced decision analysis concepts, theory, and methodology. The course covers value-focused thinking; hierarchal value structures; utility, value and scoring functions; multi-attribute utility and value problems; multi-attribute preferences under uncertainty; aggregation of individual preferences; and utilization of group preferences. Real-world applications of the course material to DoD problems are emphasized. Prerequisites: OPER 543 or OPER 646. Summer Quarter
3 credit hours

OPER 647 – QUEUING SYSTEM ANALYSIS: This course begins with an overview of stochastic modeling and transform methods. These techniques are then employed in equilibrium analysis of simple Markov and imbedded Markov queuing systems. Results are extended to address more advanced modeling concepts such as priority customers, bulk arrivals or service, generalized distributions of interarrival or service times, and networks of queues. Potential applications are discussed, including performance evaluation and optimization of communication systems, transportation networks, computer systems, and other resource-constrained operations. Prerequisites: OPER 540 or STAT 605. Fall Quarter 3 credit hours

OPER 660 – SIMULATION MODELING AND ANALYSIS: This course provides an in-depth treatment of a number of important issues in simulation modeling related to designing, performing, and analyzing statistically valid simulation experiments. Topics include random number generation, random variate modeling and generation, the structure of simulation programs, output data analysis, variance reduction, and model validation. Prerequisites: OPER 560, OPER 561, OPER 680 or STAT 696. Fall Quarter 3 credit hours

OPER 661 – OBJECT-ORIENTED SIMULATION: This course develops the concepts of object-oriented programming as applied to discrete-event simulation. The principal emphasis is on exposure to object-based techniques, and their strengths and weaknesses, in the context of modeling, simulation and analysis, Topics include an object-oriented language (such as JAVA, MODSIM, or Smalltalk), simulation and optimization libraries, basic object-oriented design concepts, HLA compliance, and complex adaptive systems. Prerequisites: OPER 561. Summer Quarter 3 credit hours

OPER 671 – COMBAT MODELING I: The purpose of this course is to present high resolution combat modeling. High resolution combat modeling provides detailed interactions of individual combatants or weapons systems. Topics include: simulating the battlefield environment, target search, acquisition and selection processes, single round accuracy and lethality models, and multiple round assessment models. Models currently in use for DoD analysis are used as examples throughout the course. Prerequisites: OPER 560 and OPER 561. Summer Quarter 3 credit hours

OPER 672 – COMBAT MODELING II: The purpose of this course is to present modeling of large-scale air/ground combat operations using aggregated force on force combat models. Topics include: aggregation and disaggregation, types of models used for large-scale operations, firepower index and Lanchester equation approaches to attrition modeling, movement, rate of advance, air allocation, logistics, and C3I models. Models currently in use for DoD analysis are used as examples throughout the course. Prerequisites: OPER 671. Fall Quarter 3 credit hours

OPER 674 – JOINT MOBILITY MODELING: The purpose of this course is to present mobility modeling from an application-oriented, large-scale point of view. Models currently in use for DoD analysis are examined. Particular attention will be given to the air mobility problem and its relation to land and sea mobility. Both strategic and theater mobility are explored. Prerequisites: OPER 560 or 561, OPER 610. Winter Quarter 3 credit hours

OPER 676 – Information Operations Research: This course is designed to increase the awareness and integration of the relationship between Information Operations (IO) and Operations Research. The focus will be on the tools, techniques, theories, and models currently in use for IO analysis. Particular attention will be paid to current IO modeling issues. Prerequisites: None. Summer Quarter 3 credit hours

OPER 681 – Statistical Process Control: This course provides an in-depth treatment of the fundamental concepts and methods of modern statistical process control. The primary focus will be on the use of control charts for monitoring the process mean and variance. Other topics include process capability analysis, the modern role of acceptance sampling, and the use of such statistical techniques within the context of total quality management. Prerequisites: STAT 537. Winter Quarter 3 credit hours

OPER 683 – Response Surface Methodology: Emphasis in this course is directed towards understanding the basic concepts and uses of RSM to examine and quantify the effect of a large number of variables which influence a system's performance. Key topic areas are experimental design and exploration of response surfaces for determining an optimum conditions response model. Emphasis is on the application of RSM to simulation results. Prerequisites: OPER 680 or STAT 696. Summer Quarter 3 credit hours

OPER 684 – Quantitative Forecasting Techniques: This is a course in applied techniques to predict discrete time-series phenomena. The emphasis is on understanding and applying forecasting tools in analysis and management settings. Both classical smoothing methods and the Box-Jenkins methodology for model identification, estimation, and prediction are presented. Time series data are modeled and predictions made with interactive computer software. Prerequisites: OPER 680 or STAT 696. Summer Quarter 3 credit hours

OPER 685 – Applied Multivariate Analysis I: This course is oriented toward the computer-assisted analysis of multidimensional data. The course will present statistical techniques such as multiple regression, principal components analysis, canonical correlation, factor analysis, cluster analysis, discriminant analysis, and neural networks. Emphasis will be on practical application to data sets using computerized statistical packages. Prerequisites: OPER 680 or STAT 696. Spring Quarter 3 credit hours

OPER 689 – Design of Experiments for Quality Improvement: This course addresses classical and more modern approaches to the area of experimental design as applied to quality improvement. Classical analysis of variance, full factorial arrangements, and fractional factorial designs are developed. Variance reduction through the Taguchi method is explored and more accepted strategies are developed. Prerequisites: OPER 680 or STAT 696. 3 credit hours

OPER 710 – Advanced Linear Programming and Extensions: This course will explore the theoretical properties of the general linear program (LP), developing results concerning extreme points, the existence of extreme point solutions, interior point methods for LP, computational complexity, fractional programming, and current developments in LP. Prerequisites: OPER 610. Summer Quarter 3 credit hours

OPER 712 – Advanced Math Programming: This course is intended for students planning advanced study and research in the areas of mathematical programming and optimization. A continuation of material covered in OPER 612, the course covers in more detail the theoretical and topological properties of the general nonlinear programming problem. Other topics are drawn from the current literature. Prerequisites: OPER 612. Spring Quarter 3 credit hours

OPER 743 – Decision Analysis Practice: This course examines the professional practice of decision and risk analysis. The course provides new material on the selection of decision analysis topics, the interface with the decision makers and technical experts, the advanced use of decision analysis software, and the presentation of results to decision makers. Students have the opportunity to apply their knowledge and risk analysis to a real decision for a real decision maker. Prerequisites: OPER 543 (old OPER 645) or OPER 646. Fall Quarter 3 credit hours

OPER 746 – Advanced Topics in Reliability: This course develops advanced mathematical concepts for application in the reliability and maintainability areas. Topics include censored reliability data analysis, optimal preventive maintenance policies, warranty analysis, burn-in strategies and other topics of current interest. The emphasis is on both analytic development as well as actual application to data analysis. The course will consider the implications of reliability during the system design phase as well as the system operational phase. Simulation software as well as "solver" software will be utilized in class exercises. Prerequisites: STAT 687 or STAT 697. 3 credit hours

OPER 747 – Queuing Networks: This course applies results from fundamental queuing theory to complex networks of queues. Specific topics of study include the modeling and analysis of product-form networks (open and closed), BCMP networks, and networks with multiple classes of customers. Approximation methods, including diffusion and decomposition, are explored. Applications in telecommunications, transportation, and manufacturing are also discussed. Prerequisites: OPER 647. 3 credit hours

OPER 760 – Advanced Simulation: This course focuses on the state-of-the-art in simulation modeling and analysis, particularly in relation to the statistical aspects of input data modeling and/or output analysis. It is intended to provide a rigorous treatment of current issues within the simulation literature. Prerequisites: OPER 660. Winter Quarter 3 credit hours

OPER 785 – APPLIED MULTIVARIATE ANALYSIS II: PATTERN RECOGNITION: This course is a survey course in pattern recognition. The course covers Bayesian Decision Theory, parameter estimation, linear discriminant functions, multilayer neural networks, and other topics. Real-world applications will be emphasized. Prerequisites: OPER 685 or Permission of Instructor.
Fall Quarter 3 credit hours

OPER 799 – THESIS RESEARCH: Prerequisites: None. 1-12 credit hours

OPER 999 – DISSERTATION RESEARCH: Prerequisites: Approval of Research Advisor. 1-12 credit hours

Department of Systems Engineering and Management

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Department Head**:** Lieutenant Colonel Alfred E. Thal, Jr.

Introduction

The Department of Systems and Engineering Management offers a Master of Science degree in three major areas: Acquisition Management (GAQ), Engineering Environmental Management (GEE), and Information Resources Management (GIR/GIS).

Faculty

Professors

Mark N. Goltz (environmental remediation, pollution control and modeling)

Associate Professors

Charles A. Bleckmann (environmental remediation)

Alan R. Heminger (information, computers, and group problem-solving reengineering)

Michael L. Shelley (system dynamics modeling, systems analysis)

Assistant Professors

David P. Biros (deception, deception detection, and information security)

Heidi S. Brothers (engineering management)

Anthony P. D'Angelo (logistics management, federal financial management)

Peter T. LaPuma (risk assessment, pollution prevention modeling and metals toxicity)

Timothy S. Reed (strategic purchasing, acquisition management)

Michael T. Rehg (strategy, international business)

William K. Stockman (source selection, program evaluation)

Alfred E. Thal, Jr. (environmental remediation, engineering management)

Mark A. Ward (organizations, information management, metaphysics)

Instructors

Bradley J. Ayres (institutional theory, organizational governance)

Danny Holt (organizational change, development, and measurement)

Emeritus Faculty

Freda F. Stohrer (communication)

Programs of Study

Acquisition Management (GAQ)

The GAQ program is designed to provide students with the knowledge and skills needed to effectively manage and work within the Department of Defense (DoD) and Air Force (USAF) acquisition management community. The curriculum integrates a strong foundation of business management concepts and techniques with specific DoD and USAF acquisition management-related topics. The program provides the knowledge to prepare students to contribute effectively in a variety of complex and challenging roles within the military acquisition management system. The curriculum includes courses in accounting, organizational behavior, quantitative decision-making, economics, production management, logistics management, business process improvement, and project management. Applicants may submit a Graduate Management Admissions Test (GMAT) score of at least 550 in lieu of GRE scores.

The GAQ curriculum has four options that include cost analysis, contracting, systems management, and software systems management. Students pursuing either the cost analysis or systems management specialty must have completed courses in calculus up to (but not necessarily including) differential equations with a minimum GPA of 3.0. The core courses for these options are listed below:

- Accounting (AMGT 520*)
- Acquisition (SMGT 640*, SMGT 643*, SMGT 646, SMGT 647*)
- Information (IMGT 523, IMGT 669)
- Logistics (LOGM 568*)
- Operations (OPER 501)

*software systems management core courses

Courses more specific to the DoD acquisition environment include systems acquisition management, acquisition strategy, federal financial management, and contract management. In addition, students have the opportunity to focus in a specific acquisition management concentration: cost analysis, contracting, or systems management.

Environmental Engineering (GEE)

The GEE program provides students with the opportunity to learn and exercise a variety of quantitative and qualitative concepts, skills, and techniques to integrate engineering, science, and policy issues into a decision-making framework for optimum management of facility operations and environmental programs. The curriculum includes courses in engineering and technical operations management, organizational management and behavior, environmental risk analysis, economic analysis, environmental engineering, environmental management and policy, operations management, and pollution prevention. In addition, students have the opportunity to focus in a specific area such as human resource management, quantitative decision-making, applied environmental sciences, or environmental systems analysis.

The core courses for these programs are listed below:

- Environmental (ENVR 500, 502, 503, 511, 550, 642, 651, 656)
- Environmental Management (EMGT 553, EMGT 571, EMGT 652)
- Operations (OPER 501)
- Organizational (ORSC 542)

Information Resource/Information Systems (GIR/GIS)

The GIR/GIS program is designed to provide students with the knowledge and skills needed to oversee the information management and information systems needs of Air Force and DoD organizations in future assignments as middle and upper-level managers in the communications and information officer career field. The GIR program provides students with a broad perspective of DoD information issues, including information architectures, process support, and the implications of rapidly evolving information technology. The focus is on improving the student’s understanding of, and ability to manage information in, today’s dynamic information technology environment. The courses that constitute the core of this program include IMGT 530, IMGT 560, IMGT 651, IMGT 657, IMGT 680, IMGT 684, IMGT 669, and IMGT 690. Applicants may submit Graduate Management Admissions Test (GMAT) score of at least 550 in lieu of GRE scores.

Research

The Department of Systems and Engineering Management is an eclectic collection of programs with broad-based research agendas. With respect to acquisition management, research is conducted in general aviation development, source selection, public-private competition, program management, and evaluation techniques. In the environmental management arena, the department has research interests in wastewater analyses and treatment, hazardous waste identification and management, land treatment of wastes, groundwater monitoring and remediation, biodegradation, bioassays, environmental compliance audits, metal toxicity, and pollution prevention. With respect to the management of information systems, the department conducts research in deception and deception detection in information technologies, information warfare, biases in communication, diffusion of innovations, media richness, computers and group problem-solving reengineering. The department also conducts research on environmental attitudes, organizational change, organizational structure and design, organizational culture, human personality and emotions, survey development, strategic management, organizational change, whistle-blowing, organizational structure, ethics (especially metaphysics), regression analysis, measurement scales, aerospace defense and international management. In the engineering management arena, research interests include outsourcing and privatization, wartime and contingency readiness, innovative contracting method, operations management, and infrastructure issues.

Course Offerings

AMGT 520 - MANAGERIAL ECONOMICS I: Considers the nature of economic incentives facing consumers, workers, and businesses. The relationship of production to cost is examined and the firm's decision about how much to produce is analyzed and related to the ability of the firm to set the price of its product under various market conditions. Also, the role and impact of government is studied from a microeconomic perspective. Prerequisites: None. 3 credit hours

AMGT 559 - LIFE CYCLE COST AND RELIABILITY: This course explores the concepts and methodologies which should be considered in the development or improvement of Life Cycle Cost (LCC) models. The different types of LCC models are defined and the limitations of specific models in use are discussed. Since LCC is very heavily influenced by reliability, the component and system reliability is studied and related to the benefits and life cycle cost impacts of reliability and of reliability improvement warranties. Prerequisites: None. Spring Quarter 3 credit hours

AMGT 600 - COST MANAGEMENT: The objective of this course is to familiarize the student with selected concepts of managerial accounting, enhancing the student's ability to develop plans, establish objectives, evaluate alternatives, control operations, identify and analyze complex problems, and make decisions. Topics to be covered include cost terminology, cost behavior patterns, cost-volume-profit analysis, job order costing, activity-based costing, activity-based budgeting, process costing, overhead allocation, responsibility accounting, cost/schedule control systems criteria, the role of uncertainty/risk in decision models, and discounted cash-flow analysis. To the extent possible, classroom discussions and assignments include examples specific to the Department of Defense. Prerequisites: AMGT 336 or instructor's permission. 3 credit hours

AMGT 602 - FEDERAL FINANCIAL MANAGEMENT: This course begins with an in-depth survey of contemporary thought regarding the application of Management Control Systems (MCS) concept to non-profit organizations. This development of theory provides a conceptual base for studying MCS hypotheses as they are applied within the federal government in general and the Department of Defense in particular. Focus of the course is on the Department of Defense's Resource Management Systems and provides students with a professional understanding of the structures and processes which govern the allocation of national resources, especially as they pertain to the military establishment. Topical references to Presidential and Congressional budget approaches and problems are made throughout the course. Specific topics addressed include various aspects of federal resource allocation, the Unified Federal Budget, the congressional budget process, the appropriation process, fund control requirements, the Resource Management System, the Planning, Programming and Budgeting System, performance measurement, and the inventory management system. Prerequisites: None. 3 credit hours

AMGT 610 - FINANCIAL MANAGEMENT CONTROL SYSTEMS IN GOVT: The objective of this course is to provide future Department of Defense (DoD) decision makers with an understanding of management control systems, to include managerial accounting and financial management techniques used by decision makers throughout the public and private sectors. The course provides an understanding of how accounting and financial management support both the planning and controlling of routine operations and making non-routine decisions, while providing the internal control necessary to facilitate mission accomplishment and effective stewardship. Specific knowledge about budgets, costs, and cost accumulation and allocation systems is included. This course provides an understanding of DoD resource management systems, especially the nature and function of the Biennial Planning Programming and Budgeting System (BPPBS) and the Future Years Defense Program (FYDP); the Executive and Congressional budget processes; and the interrelationships between these systems and processes. This includes an awareness of the structure and importance of Unified Federal Budget of the United States. Prerequisites: AMGT 336 or equivalent college level course with a grade of C or better. Summer Quarter 4 credit hours

AMGT 620 - MACROECONOMICS AND PUBLIC POLICY: Focuses on the circular flow of activity in the industrial economy and on the policies invoked by central government to influence national output, employment, income, and economic growth. National income accounting is discussed, and national income determination is investigated from various theoretical perspectives. The business cycle, international transactions, inflation and the role of money are among subjects examined in detail. Prerequisites: None. 3 credit hours

AMGT 699 - DIRECTED STUDY IN SYSTEMS ACQUISITION MANAGEMENT: This course allows a student to study a topic area not generally offered in a scheduled class setting. Students must arrange such a course with a member of the graduate faculty and gain approval of their academic advisor. The course will be treated as an elective in the student's program of study and only one such elective will be allowed. Directed study carries three graduate credits and the work done should be commensurate with that value. Directed study cannot be taken on a student's thesis topic since that is provided for under independent study. Prerequisites: None. 3 credit hours

CMGT 520 - SYSTEMS CONTRACTING MANAGEMENT: This is the first course in the Graduate Contracting Management program and focuses on the DoD contracting processes used to obtain and support major defense systems. It begins with the exploration of the role of contracting in the acquisition process, the differences between government and corporate purchasing/ contracting, and the relationships between buyer and seller. The remainder of the course provides an in-depth coverage of the pre-award contracting process as normally practiced in the systems arena. This includes requirements determination and acquisition planning, the solicitation process, negotiation, source selection, and contract award. The course concludes with a discussion of ethics and recent initiatives aimed at reforming and improving both the acquisition and contracting processes. The overall objective of the course is to help contracting students understand the role of contracting in the acquisition process and in identifying ways that the contracting process can be improved to better meet customers' needs. Prerequisites: None. Winter Quarter 3 credit hours

CMGT 523 - CONTRACTING AND ACQUISITION MANAGEMENT: This survey course introduces students to the DoD contracting and acquisition processes. Through classroom discussion and outside readings, the student is introduced to the overall weapon system acquisition environment, the acquisition process, the entire contracting process, and current ethical and reform issues. The objective of the course is to help students understand the role of contracting in the acquisition process as well as to assess their role and stake in these processes, whether it be as a user, developer, supporter, or manager of a weapon system. Prerequisites: None. 3 credit hours

CMGT 524 - CONTRACTING FOR ENGINEERS: This course provides graduate level education in the application of technical, legal, and management principles in preparing and managing military service and construction contracts. Through classroom instruction and supplementary reading, the students will be prepared to apply contracting principles to engineering and services contract situations. Prerequisites: None. 3 credit hours

CMGT 526 - PURCHASING IN SUPPLY CHAIN MANAGEMENT: The DoD acquisition community is seeing an unprecedented change in the philosophy and way we do business. One major change is the emphasis on use of commercial practices. In order for this change to be effective, DoD acquisition and logistics personnel must be familiar with how and why commercial firms acquire, handle and control goods and services. The purpose of this course is to familiarize the students with the current theory and practices of commercial firms in dealing with suppliers. This course will introduce the students to acquisition in the commercial firms in dealing with suppliers. This course will provide the students with a basis to be able to evaluate and consider incorporation of applicable practices into government practice. This course covers all areas of commercial firms involvement with suppliers to include purchasing, transportation, supply management and logistics. Prerequisites: None. Fall Quarter 3 credit hours

CMGT 550 - SYSTEMS PRODUCTION MANAGEMENT: A primary objective of acquisition management is to obtain major weapon systems needed by the defense community. The discipline of manufacturing management plays a vital role in acquiring these systems within the cost, schedule, and technical goals of the program. Therefore, acquisition professionals must understand the roles that government and industry manufacturing managers play in the acquisition process. This course introduces the student to the manufacturing field. Manufacturing topics covered include manufacturing methods and processes, work measurement, quality management, statistical process control, line of balance, learning curve analysis, and inventory management. The course also addresses the importance of a strong industrial base, the importance of proper planning for the production phase of the acquisition process, and the impact of funding decisions on the transition from system development to system production. Prerequisites: None.

3 credit hours

CMGT 552 - SEMINAR IN CONTRACT MANAGEMENT: The second course in a two-part series, CMGT 552 will concentrate on "post-award" contracting matters. Often referred to as "contract administration", post-award contracting matters range from the fairly simple corrections found in an administrative modification to the very complex issues associated with a major weapons systems bilateral modification. The overall objective of CMGT 552 is to help participants gain a thorough understanding of the many facets of systems contract administration. To that end, the course has been designed as a continuance of CMGT 520 (Systems Contracting Management). After reviewing the basic concepts of contract administration, the participants will take an in-depth look at contract interpretation, risk allocation, changes, and contract delays. Once they have gained an analytical appreciation of the issues at hand, the participants will be required to apply this knowledge, as well as pricing concepts associated with them. Next the participants will take a closer look at the issues of inspection and acceptance, with particular attention being paid to the implication of these actions on the relative rights of the parties. Finally, the participants will examine the issue of contract closure. By looking at the whole range of contracting administration issues, (particularly in such depth) it is believed that the participants will leave the classroom well-equipped to not only identify contract administration issues, but be prepared to effect innovative and effective solution to these issues. Prerequisites: CMGT 520. Spring Quarter

3 credit hours

CMGT 635 - SEMINAR IN CONTRACT NEGOTIATION: This seminar will refine the negotiation skills of the student through the use of readings, class discussions, case analyses, and practical exercises. Students will be introduced to various styles and approaches to negotiation. This will include determining appropriate goals, objectives, and strategies and then using appropriate tactics and methods to achieve them. The course will also help students understand the role of communication, power, and personality in the negotiation process and to assess their own personal abilities and traits as they relate to negotiation. While the course will focus on negotiation of defense contracts, the principles covered will apply to the entire range of interpersonal relationships. Prerequisites: None. 3 credit hours

CMGT 654 - SEMINAR IN ACQUISITION MANAGEMENT: This seminar course is designed to enhance each student's awareness and knowledge of the current issues affecting the system acquisition process in DoD. More specifically, the course also focuses on the role of the contracting function within the acquisition process. Given that context, the course builds upon concepts, principles, and procedures embodied in earlier courses, and provides each student the opportunity to develop his or her own philosophy regarding acquisition management and systems contracting. Toward that end, the following teaching methods are employed: student research and seminar presentations, instructor-led seminars and guest speakers (government and/or industry, as available). Prerequisites: CMGT 520, 552 or equivalent. 3 credit hours

COMM 310 - FUNDAMENTALS OF WRITTEN COMMUNICATION: Refresher course in basic aspects of written expression, including grammar, mechanics, usage, style, logic, and organization. Course work consists of class discussion and self-study exercises. Students are identified as candidates for enrollment through evaluation of written communication skills examination administered during orientation week. Prerequisites: None. 0 credit hours

COMM 680 - TECHNICAL REPORTS AND THESIS: Prepares students to present scientific/technical material in oral and written reports. Topics covered include the communication situation; elements of precise, concise style; organizing information for oral and written presentation; methods of locating and evaluating published technical information; techniques of accurate documentation; and local and general conventions of briefings and reports. Requires three papers and two briefings. Prerequisites: None. 3 credit hours

COMM 693 - SEMINAR IN PROFESSIONAL MILITARY ETHICS: Studies in military professionalism and just war theory by examination of several case studies, identifying ethical problems and evaluating results of commander's decisions. Students are invited to examine personal ethical standards, applying them to real-world cases, coming to a better understanding of the military officer in contemporary affairs and high-stress situations, including combat, program management, POW status, and counter-terrorism. Four written assignments and one briefing demonstrate competence in ethical analysis. Prerequisites: None. 3 credit hours

COST 668 - COST ANALYSIS COLLOQUIUM: This course exposes students to current, real-world issues, problems, and practices of the defense cost analysis community as viewed by senior individuals and practitioners in the field. The structure of the colloquium consists of approximately 15 presentations by individuals from the cost analysis community during the course of the graduate program. Each guest speaker typically makes a one hour presentation on a selected topic (e.g., a current independent cost analysis) which is followed by an open discussion to allow as much interaction between the guest speaker and students as possible. The presentations focus on cost estimating management, processes, problems, and action taken to mitigate the problems. Prerequisites: None. 0 credit hours

COST 669 - ADVANCED COST ANALYSIS: COST 669 introduces the student to the cost analysis profession. The course is designed to develop a realistic perspective on the part of the student concerning the tasks a cost analyst is expected to be able to perform, the techniques and methodologies available to the analyst to accomplish the job, and the environment in which the cost analyst will operate. The course includes important information about the role of the cost analyst in the Planning, Programming, and Budgeting System and DoD acquisition process, as well as an introduction to contracting, thus meeting the prerequisites of SMGT 647. The course is a collection of topics, each of which addresses a particular element of the cost analyst's job or environment. The topics are designed to develop a framework of understanding which allow the student to relate the value of specialized material to be covered in subsequent courses to the overall requirements of the cost analysis profession. Prerequisites: None. Winter Quarter 3 credit hours

COST 674 - SEMINAR IN COST ANALYSIS: This seminar is the capstone course in the Cost Analysis curriculum. Its purpose is to integrate the material covered in the curriculum and to introduce the students to current topics and issues of interest to the cost analysis community. The seminar explores current concepts and applications of cost analysis, the demands of Life Cycle Cost management and analysis, and the role of Economic analysis. Other current topics are included as appropriate. Prerequisites: COST 669. 3 credit hours

EMGT 530 - CONTRACT MANAGEMENT: The purpose of the course is to provide students with an introduction to the contracting process used by the Department of Defense. The focus is on understanding and effectively managing construction and service contracts. The course is divided into two sections: first, an introduction to the contracting process and second, tailored lectures addressing specific contracting issues like Privatization, Outsourcing and Contingency Contracting. Prerequisites: None. 3 credit hours

EMGT 552 - ENGINEERING AND ORGANIZATIONAL MANAGEMENT: This course is designed to introduce the student to the principles and theories of management as they apply to a technical organization. The distinctions between management of technical versus other types of organizations are covered, as are the legal, ethical, and moral obligations of engineers in managerial positions. The course also explores the various principles of engineering management as they apply to leadership, communication, and personnel management, production, planning and strategy. Prerequisites: None. Winter Quarter 3 credit hours

EMGT 553 - OPERATIONS MANAGEMENT: This course introduces the student to a variety of operations management techniques, such as forecasting, capacity planning, facility layout, inventory management, and scheduling. Instead of utilizing the traditional context of a manufacturing environment to develop the topics, the course is tailored to the requirements of physical plant operations and maintenance activities. Prerequisites: None.
3 credit hours

EMGT 571 - PUBLIC INVESTMENT ECONOMICS: This course covers the theory of supply and demand, production and cost, externalities and the role of the government, and the use of present value in evaluating government projects. The purpose of the course is to provide the student with the background in economic theory necessary for understanding the principles of benefit-cost analysis as applied to problems in environmental management. Prerequisites: None.
3 credit hours

EMGT 774 - ENGINEERING MANAGEMENT STRATEGY: This course serves as a capstone to the Engineering Management sequence, drawing upon the shared and collective experiences of the students in the sequence. Strategies of engineering management comprise traditional management roles of planning, organizing, leading , and controlling the human, financial, material, and intellectual resources of a highly technical corporate body in order to further its long-term objectives. The purpose of this course is to expose students to this strategic approach through case studies and hands-on projects which require a thorough, multifaceted analysis of actual situations confronting practicing engineering managers. Elements of project management and development of such skills as decision making, forecasting, communicating, motivating, and team building will be highlighted. Prerequisites: ENVR 552 and OPER 629. Fall Quarter 3 credit hours

ENVR 501 - ENGINEERING AND ENVIRONMENTAL MANAGEMENT CURRICULUM OPTIONS: This seminar presents the proper approach to performing student research as part of the Engineering and Environmental Management Program requirements. Various faculty will speak on how to choose a research project, milestones to establish, and expectations of the completed research. Other departments will present course sequences comprising supporting program options as they relate to preparing the student for a specific research approach. Finally, selected students from the graduating class will present their research approaches as examples. Prerequisites: None. Fall Quarter
0 credit hour

ENVR 502 - RESEARCH PERSPECTIVES: This seminar presents the principles of organizing and conducting research. Students are introduced to scientific literature, theory, research objectives and methodologies. Thesis construction, development and timelines are discussed. The seminar serves to help students to complete their thesis prospectus and prepare to conduct graduate level research. Prerequisites: None. Winter Quarter
0.5 credit hours

ENVR 503 - CRITICAL REVIEW OF RESEARCH LITERATURE: The purpose of this seminar is to provide students with an introduction to research literature in a specific topic area of engineering and environmental management, and to prepare the student for conducting critical reviews of research literature. Several seminar groups will be formed; each led by faculty member(s) and defined by a general research topic. Students will lead discussions within their groups on a published research paper. Literature review documentation and thesis proposal requirements will also be discussed. Prerequisites: None. Spring Quarter 0.5 credit hours

ENVR 511 - ENVIRONMENTAL MANAGEMENT AND POLICY: This course is designed to provide an intensive introduction to the field of environmental management and policy, including basic concepts and approaches, major elements of American environmental policy, political processes and institutions, public policy tools, and environmental policy analysis. Prerequisites: None. Winter Quarter 3 credit hours

ENVR 528 - ENVIRONMENTAL PHYSIOLOGY AND TOXICOLOGY: A general knowledge of physiology and toxicology is critical to understanding the many health effects that can occur from environmental exposures to chemicals. Human health is the primary motivation behind many environmental activities from spill clean up goals to pollution prevention. This introductory level course will cover the physiology of each major organ system in the human body along with the types of injury that can occur to each organ system from chemical exposure. Specific areas covered are cell physiology, genetics, cancer, respiratory system, cardiovascular system, nervous system, digestive system, kidney, liver, immune system, endocrine and reproductive system. This course will enhance the student’s ability to comprehend medical health information. The course provides a strong foundation in human health effects, which will result in well informed decision making concerning health related issues. Prerequisites: None. 4 credit hours

ENVR 532 - AIR RESOURCE MANAGEMENT: An air pollution survey course to advance the student's knowledge of the sources, emissions, health and environmental effects, dispersion and transport, atmospheric interactions, federal laws and regulations dealing with air pollution. It includes a discussion of current air pollution topics (e.g. 03 depletion, acid rain, global warming) needed for the management of the air resources in our society. Prerequisites: None. 3 credit hours

ENVR 535 - SOLID & HAZARDOUS WASTE MANAGEMENT: This course provides an understanding of the problems of solid waste and hazardous waste Management. Collection, storage, treatment, and disposal technologies and regulations will be discussed, with emphasis on sound engineering and economic solutions. Public health and risk communication issues will be addressed, as will the responsibilities of waste generators, transporters, and managers of waste control facilities such as landfills and incinerators. Prerequisites: None. 3 credit hours

ENVR 550 - ENVIRONMENTAL SYSTEMS ENGINEERING: This course provides the student with analytical and mathematical tools to quantitatively and qualitatively assess the effect of Air Force operations on the environment. The course helps the student understand the basic engineering controls that can be used to minimize the impact of mission operations on the environment. Topics include: basic environmental chemistry and physics; unit processes; fate and transport of contaminants; physical, chemical and biological treatment alternatives; mitigation of air, water, and soil pollution. Prerequisites: None. Fall Quarter 4 credit hours

ENVR 580 - ENGINEERING ECONOMIC DECISION ANALYSIS: This course studies the analytical techniques necessary to optimize the economic outcome of technical and managerial decisions. Traditional engineering economic concepts (time value of money) are reviewed before presenting more complex concepts such as life-cycle cost concerns, comparison of alternatives, analysis of risk and uncertainty, and decision models. Prerequisites: None. 3 credit hours

ENVR 626 - FATE AND EFFECTS IN BIOLOGICAL SYSTEMS: This course presents the basic structure of biological systems (including mammalian physiology) with emphasis on their vulnerability to toxic insult from environmental contamination. Xenobiotic metabolism (both human and ecological) is quantitatively studied in terms of its role in the expression of toxic effects. The effects of specific contaminant classes on various systems are presented in light of their significance. Specific toxic mechanisms (both validated and proposed) are explored. Mathematical modeling approaches are developed in the areas of pharmacokinetics, pharmacodynamics, and risk extrapolation techniques. Quantitative cancer modeling is included. Prerequisites: CHEM 590, STAT 526, STAT 536 (Corequisite:ENVR 651) Spring Quarter 3 credit hours

ENVR 622 - ECOSYSTEM DYNAMICS: (NOTE: Students enrolling in this course should not enroll in ENVR 534) This course presents the dynamics of ecosystem processes with emphasis on the cycling of organic and inorganic material in maintaining homeostasis and how environmental contaminant transport behave within this system. Population dynamics are also included. The mechanisms of contaminant transport and accumulation between and within ecological compartments are considered, including biological tissue. Specific toxicological endpoints are associated with the presence of contaminants in various system compartments. Deterministic methods for predicting transport, accumulation, and magnification are developed and exercised. Prerequisites: CHEM 590, ENVR 651, ENVR 621. Summer Quarter 3 credit hours

ENVR 623 - ENVIRONMENTAL TOXICOLOGY: This course provides detailed coverage of the specific effects of chemicals and chemical classes on living organisms at the cellular, tissue, and organism levels. Effects of natural and anthropogenic materials on the health, behavior, and reproduction of individual plants, animals, and microorganisms are examined, as well as accumulating and cascading effects throughout ecosystems. Topics include types of toxicants, sources of exposure, levels of impact, mechanisms of impacts, and identification and testing of effects. Prerequisites: ENVR 550. 3 credit hours

ENVR 625 - ENVIRONMENTAL MICROBIOLOGY: This course describes the principles of biological sciences as they relate to and impact environmental systems. Microbial systems serve as models to demonstrate the complex interactions between living organisms and the physical/chemical environment. The role of microorganisms and microbial processes in environmental problems, both positive and negative, will be investigated. Specific topics include microbial physiology and genetics, aerobic and anaerobic systems, biochemical pathways, nutrient cycles, pathogens and wastewater, and bioremediation of soils and groundwater. Prerequisites: ENVR 640. 3 credit hours

ENVR 640 - Groundwater Hydrology and Contaminant Transport: This course introduces the student to hydrogeological concepts. The course discusses the occurrence and movement of groundwater in a variety of geologic settings, as well as the fate and transport of contaminants in the groundwater. Also discussed are methods of sampling, site characterization, water chemistry, well hydraulics, computer modeling of flow and transport, and groundwater restoration technologies. The student is expected to have a working knowledge of college algebra, calculus and differential equations. A background in college chemistry is also necessary. Familiarity with computer modeling of physical systems is helpful. Prerequisites: MATH 001 or Consent of instructor. 3 credit hours

ENVR 642 - System Dynamics Modeling: This course describes the methodology used for portraying and analyzing the behavior of holistic systems. It introduces the concepts of "systems thinking" developing the tools for modeling complicated system of multiple feedback loops typical of environmental interactions. The systems modeling software "STELLA II" is used to develop modeling concepts and to apply system modeling. The examples within the course are chosen for applicability to current environmental issues. Prerequisites: None. Spring Quarter 3 credit hours

ENVR 643 - Environmental Transport Processes: Starting with the law of conservation of mass, this course introduces students to the processes that govern the fate and transport of contaminants in the environment. Examples of transport processes relevant to the three main environmental media--air, water, and soil, are presented. Processes such as diffusive mass transport, convection-dispersion (transport with fluid momentum), filtration, and adsorption are discussed, with examples showing how each process affects contaminant fate and transport in several environmental media. A section of the course is devoted to reaction kinetics and reactor modeling. Students completing this course will better understand how contaminants move about and change in the environment, as well as how transport processes can be engineered to control contamination. Prerequisites: None. Winter Quarter 4 credit hours

ENVR 651 - Environmental Risk Analysis: This course combines environmental engineering, epidemiology, toxicology, and risk management to provide tools for students to:(1) identify environmental impacts and health problems associated with a variety of activities and substances (e.g., hazardous waste disposal); (2) compare new and existing control technologies to reduce risks and improve mitigation efforts; (3) develop site selection criteria for potentially hazardous facilities; and (4) determine environmental management priorities (e.g., prioritizing corrective actions). The course discusses methods for modeling risk and contaminant pathways. Various approaches to the use of risk assessment information in light of social, cultural, economic, and legal constraints, as well as public relations in risk communication, are presented. Prerequisites: None. 3 credit hours

ENVR 653 – ENVIRONMENT IMPACT ASSESSMENT: This course studies the environmental impact assessment process and the application of principles and practices associated with that process to the preparation of environmental assessments and impact statements in the United States. Legislation and regulations will be summarized along with methods for planning and scoping the studies, identifying impacts, describing the affected environment, predicting and assessing impacts, selection of the appropriate option and applicable mitigation steps, and public participation. Impact prediction and assessment approaches will be discussed relating to various physical, chemical, bilogical, cultural, and socio-economic media. Emphasis will be placed on the importance of effective communication. Prerequisites: ENVR 511, ENVR 550.
3 credit hours

ENVR 656 - POLLUTION PREVENTION: This course introduces the student to many technical and management concepts and techniques that can be used to develop a program for minimizing the impact of Air Force operations on the environment by reducing or eliminating pollution at the source. Various qualitative and quantitative techniques are presented for source reduction and management of hazardous and toxic chemicals, solvent substitutions, reuses and recycling, and process evaluation and changes. Pollution prevention requirements of Federal, state, local laws and Air Force regulations are addressed. Prerequisites: ENVR 550, ENVR 571. 3 credit hours

ENVR 699 - DIRECTED STUDY: This directed study course allows individual students, under the direction of a faculty member, to pursue topics not generally offered in a scheduled class setting. This course (1) must be commensurate with the credit value awarded, (2) must be approved by the student's Academic Advisor and Department Head, (3) must be a topic independent of student thesis research and (4) cannot be repeated. Prerequisites: Permission of Instructor.
Variable credit hours

ENVR 772 - REMEDIATION DESIGN AND MANAGEMENT: This upper level class investigates the physical, chemical, and biological methods used in remediation of environmental contamination in soils, surface water, and ground waters. Processes to address contamination, including the no-action alternative, contaminant techniques, and pump-and-treat and in situ technologies, will be reviewed in sufficient technical background to apply the basic engineering design equations, but with emphasis on practical applications. Included is a review of regulatory requirements that often determine the remediation process, including the National Contingency Plan and the RI/FS process. Mechanisms for selection of appropriate treatment technologies will be described. Prerequisites: ENVR 625, ENVR 640, (CHEM 685 desirable). Fall Quarter
3 credit hours

ENVR 775 - STRATEGIC ENVIRONMENTAL MANAGEMENT: This course builds from the science foundation established through the prerequisites and integrates that knowledge into planning, design, and management activities. Environmental planning includes ecological considerations in human development activities. Similarly, environmental design includes life cycle and impact considerations in product and process design decisions. Environmental management introduces the organizational, directional, and control activities required to sustain an ecological perspective within an organizational context. Prerequisites: ENVR 622, ENVR 623. fall Quarter 3 credit hours

ENVR 799 - INDEPENDENT STUDY : Thesis research. Prerequisites: None. 1-12 credit hours

IMGT 523 - MANAGEMENT INFORMATION SYSTEMS: This course is designed to prepare students for the ever-changing demands of information systems management. Specifically, the course explores leading information technology topics to include technical foundations, telecommunications and networking, hardware and software architectures, and system security and control. Management oriented topics include the strategic role of information systems, knowledge management, organization redesign with information technology, and ethical and social impacts of information systems. The primary objective of this course is to give students a firm foundation of information technology knowledge that can be applied to any career field. Prerequisites: None. Summer Quarter 3 credit hours

IMGT 530 - CONCEPTUAL FOUNDATIONS FOR INFORMATION RESOURCE MANAGEMENT: Provides an overview of the broad range of concepts and theories on which academic study of information resource management is based. The course examines the role of information and control systems in supporting organizational functions from routine operational processes to strategic planning and decision making. It also surveys the primary directions that current information systems research is taking and identifies how a variety of research methodologies may be applied to information resource management research questions. Prerequisites: None. Fall Quarter 4 credit hours

IMGT 560 - TECHNICAL AND MANAGERIAL FOUNDATIONS OF INFORMATION RESOURCE MANAGEMENT: This course provides Information Resource Management and Information Systems Management professionals with the necessary background for information management in the DoD environments by providing both the technical underpinnings of the information systems field as well as the organizational theory required for the development of rational planning, sound strategy, and appropriate economic justification. Topics addressed include information systems organization and management, computers, software, and telecommunications, designing information systems, using information systems to enhance managerial decision making, and the ethical and social impacts of information systems. This course includes case studies where teams of students will use the Internet to obtain information. Prerequisites: None. Winter Quarter 3 credit hours

IMGT 561 - APPLICATIONS OF DATABASE MANAGEMENT SYSTEMS: With emphasis on data in information systems, and with the increasing complexity of data management, this course explores the applications of computer database systems to support organizational and administrative functions. More specifically, the course covers from both a user's and a designer's perspective: the concept of database management systems (DBMSs); DBMS security, integrity, recovery, and concurrency considerations; DBMS data models (the relational will be emphasized, but the hierarchical and network models will also be covered); data manipulation; and database design. Principles studied will be reinforced in the laboratory. Students will use a relational DBMS to build a management-oriented application. Prerequisites: None.
4 credit hours

IMGT 651 - SYSTEMS ANALYSIS AND DESIGN: This course provides an in-depth study of the methodologies currently used in the analysis and design of information systems. Strategies for conducting system requirements analysis and methods for accomplishing the logical specifications of information systems are discussed at length. Techniques and tools used to complete the detailed logical and physical design are discussed in-depth. Prerequisites: None. Spring Quarter
3 credit hours

IMGT 657 - DATA COMMUNICATIONS FOR MANAGERS: Introduces concepts of data communication systems, balancing technical and managerial issues, to prepare managers to participate in decisions regarding data communication applications. Topics addressed include industry standards, hardware and software requirements for controlling the flow of data, transmission media, security, and trends in the telecommunications industry. Prerequisites: None. Spring Quarter 3 credit hours

IMGT 658 - LOCAL AREA NETWORKS: Examines the application of data communications technology and key national and international standards to local area networks. It reviews hardware and software components of local networks and introduces concepts of distributed computing. It also presents management issues in selecting/implementing local area networks to support organizational information processing. Prerequisites: IMGT 657.
3 credit hours

IMGT 663 - HUMAN-COMPUTER INTERACTION: This course explores the principles of Human-Computer Interaction (HCI) and its relevance for the design, implementation, and testing of information systems. Issues covered in this course include: The discipline of HCI and its relationship with IRM; The nature of interaction; User centered design; User and task analysis; Usability engineering; Evaluation strategies; User acceptance of information technology; Theory vs. Empiricism in HCI. Prerequisites: None. 3 credit hours

IMGT 669 - BUSINESS PROCESS IMPROVEMENT: This course presents the concepts of business process reengineering and the goals for their use in the Department of Defense and the U.S. Air Force. Analysis techniques such as strategic planning, activity modeling, process modeling, activity based costing, benchmarking, data modeling and functional economic analysis are presented to illustrate methods for evaluating existing and proposed business processes. These techniques are then used to illustrate development of a business case that supports reengineering business processes and defining requirements for process improvement, including the improvement of supporting information systems. Prerequisites: None. Summer Quarter 3 credit hours

IMGT 680 - KNOWLEDGE MANAGEMENT: This course explores the developing concept of knowledge management, which includes the managerial issues of managing organizational information as a valuable resource, and the technical issues of how to most effectively gather, organize, store and disseminate that information in an evolving information technology (IT) environment. Prerequisites: None. 3 credit hours

IMGT 687 - MANAGERIAL ASPECTS OF INFORMATION WARFARE (IW): This course explores management and policy issues relevant to information warfare. Students will be introduced to the emerging issues in this new field, and will explore developing management and policy issues being addressed by the Air Force and the other DoD Services. Issues covered in this course include evolution of information warfare as a concept, history of DoD and Air Force information doctrine, impact of emerging technology on the management of information warfare, role of IRM in the management of IW and offensive and defensive issues for IW. Prerequisites: None. 3 credit hours

IMGT 690 - SEMINAR IN INFORMATION RESOURCE MANAGEMENT: IMGT 690 is the capstone course for the GIR/GIS program that serves two purposes. First, the seminar is used to pull together the many concepts and issues covered in the program and it strives to put them into a context that will help the students to prepare for using what they have learned to meet Air Force needs. Second, it provides a forum in which subjects of special interest can be addressed and explored in some depth. These subjects may change over time, as the field evolves, and as the needs of the Air Force change. With the seminar format, the students are expected to assume responsibility for developing and making classroom presentations on selected topics, and to take an active part in classroom discussions. Prerequisites: None. Winter Quarter 3 credit hours

IMGT 695 - INFORMATION RESOURCE MANAGEMENT COLLOQUIUM: Provides a forum for discussion of high level Air Force information policy with top leaders, academics, and professionals. Prerequisites: None. 0 credit hours

ORSC 542 - MANAGEMENT AND BEHAVIOR IN ORGANIZATIONS: Provides student with understanding of theory and research in management and organizational behavior. Perspective is both "macro" and "micro". Topics include foundations of management thought, managerial functions, organizational effectiveness, organization theory, motivation, leadership, and group dynamics. Prerequisites: None. 4 credit hours

ORSC 638 - SEMINAR IN CONTEMPORARY LEADERSHIP THEORY AND APPLICATION: This course has the dual goals of providing in-depth instruction on approaches to leadership theory and facilitating the students' growth and development as leaders, particularly in the military environment. We will examine each of the major leadership theories as well as related areas such as the process of influence, bases of power, determinants of leader behavior, and leader facilitation of group problem solving. Leadership theories will be described, evaluated, and discussed in class, also, we will focus attention on military leadership articles through student-led discussions. Prerequisites: ORSC 542, Management and Organizational Theory. 3 credit hours

ORSC 647 - ORGANIZATIONAL POLICY AND STRATEGIC MANAGEMENT: This course serves as a basis for the understanding and use of the strategic process within organizations. Students are introduced to the history and current theory dealing with the development of strategies and policies which serve to help achieve organizational goals. Major subelements of the strategy process are detailed. In addition to theoretical work, students learn practical methods for implementing and maintaining a viable strategic process within Air Force and DoD organizations. Practical experience is gained through application of theory to specific cases of business problems encountered by actual firms. Additionally, students learn how managerial strategies and decisions affect an organization first-hand, through a simulation that resembles a real-world global market over a five year time period. This gives students hands-on experience in crafting business strategy, reasoning carefully about strategic options, using what-if analysis to evaluate action alternatives, and making strategic decisions. Prerequisites: ORSC 542 or permission of professor.
3 credit hours

ORSC 652 - PERSONNEL MANAGEMENT: This course provides an overview of topics important to the field of personnel management. Major emphasis is given to timely personnel theory and research, military and civil service personnel policy, and legislative and judicial decisions molding the field today. Subject areas in the course include job analysis, performance appraisal, wage and salary administration, training and development, benefits and services, personnel recruitment and selection, and equal employment opportunity issues. Prerequisites: None.
3 credit hours

ORSC 661 - MAKING SENSE OF RESEARCH DATA: This course is designed to provide students with an opportunity to integrate and augment technical research skills learned in other courses. Furthermore, students are afforded an opportunity to practice designing research instruments, collecting data, and performing computer assisted statistical analyses in a laboratory environment prior to undertaking their own thesis research. Techni cal skills in research design, measurement theory, and statistical analyses are emphasized. Prerequisites: None.
3 credit hours

ORSC 699 - DIRECTED STUDY IN ORGANIZATIONAL SCIENCES: This course provides advanced students with a means to examine in depth selected research topics in the organizational sciences. Under the direction of a professor, the student conducts an extensive review of the literature on a selected topic and presents the results. Requires approval of the professor who will direct the studies. Prerequisites: ORSC 542 or ORSC 530.
3 credit hours

QMGT 680 - PROJECT RISK ANALYSIS: This course covers the concept of project risk with an emphasis on formal risk analysis methods. The course begins by introducing the Work Breakdown Structure as the primary vehicle for analyzing project risk. Typically, the subject matter is segregated into the areas of cost, schedule and technical risk. Cost risk will be evaluated under three basic assumptions, 1.) complete independence among WBS (cost) elements, 2.) complete dependence, and 3.) partial dependence. Both analytical and simulation methods for quantifying cost risk will be discussed. In order to cover simulation methods,

the general method of Monte Carlo simulation will be introduced. Network techniques for project scheduling will be covered in order to examine schedule risk. Once again, Monte Carlo simulation will be used to evaluate schedule risk under the assumption of independence of WBS elements. Technical risk will be discussed and methods of nominal ratings and scoring models will be introduced. Finally, the problem of integrating these analyses into a total measure of risk will be discussed. Methods for documenting and presenting risk analysis will complete the course. Prerequisites: QMGT 670, STAT 525, STAT 592 or equivalent.
3 credit hours

RSCH 630 - RESEARCH METHODS: Provides the student with detailed information on basic research methods and concepts. Considers problem identification and delimitation, data gathering, information, measurement, classification of variables, validity and reliability, research populations and sampling, and designs to test research hypotheses and answer research questions. Explains how to combine these elements into an acceptable research proposal. Written assignments examine reading assignments present literature searches, and critique published research. Prerequisites: None.
3 credit hours

RSCH 631 - QUALITATIVE RESEARCH METHODOLOGY: Course objectives are to present the range of qualitative research methods which might support student thesis projects; to describe the logic behind and need for qualitative perspectives in management research; and, to present techniques for enhancing reliability and validity in qualitative research. Requires two group projects and an individual thesis research proposal. Prerequisites: RSCH 630 or equivalent (or permission of instructor). 3 credit hours

RSCH 662 - ORGANIZATIONAL METRICS, SURVEYS, AND INSTRUMENT DEVELOPMENT: Provides students with the specific competencies needed to develop high quality metrics, surveys, and other organizational measures that support management decision-making. Students will learn relevant aspects of psychometric theory, test and measurement methods, and approaches toward generating questionnaire items. Course requirements include four projects. Each project will involve designing, pilot-testing, and evaluating a metric or instrument. Emphasis is on developing, using, and interpreting surveys to support decision-making in applied settings. Prerequisites: RSCH 630 or equivalent (or permission of instructor).
3 credit hours

RSCH 790 - RESEARCH PROJECT FOR MOBILITY MANAGERS: This is a research paper specifically for the graduate students in the Masters of Mobility Operations program offered at the Air Mobility Warfare Center (AMWC). The topic of the paper will be selected by the student in consultation with the student advisor at AMWC and a faculty advisor at AFIT. The objective of the paper is for the student to undertake and complete a research project related to strategic air mobility, using the techniques and knowledge acquired in their graduate program. Prerequisites: None. 4 credit hours

RSCH 799 - THESIS RESEARCH STUDY: Prerequisites: None. 1-3 credit hours

SMGT 343 - SYSTEMS ACQUISITION MANAGEMENT OVERVIEW: The purpose of this course is to provide new GSM students who have little or no acquisition management experience with the background information acquired by experienced acquisition managers in their Professional Continuing Education courses and in their work experiences.

The course presents both the DoD and Air Force perspectives on acquisition management and provides an overview of the Defense Acquisition process. Key topics covered include contracting, planning, scheduling, performance management, integrated logistics support, test and evaluation, systems engineering, configuration management, and an introduction to the integrated weapon system management (IWSM) concept. This is a survey course to provide the background necessary for the acquisition courses in the GSM curriculum. Prerequisites: Acceptance into GSM Program. 3 credit hours

SMGT 543 - SYSTEMS ACQUISITION MANAGEMENT: This is a three-hour lecture and discussion course on systems acquisition management. Because of the mixture of students who take this course, acquisition management is covered primarily from the DoD perspective, but some Air Force specific topics are covered. Key topics covered in the course are requirements generation; contracting; the acquisition life cycle; acquisition planning; integrated logistics support; the planning, programming, and budgeting system; test and evaluation; systems engineering, configuration management; and data acquisition and management. Prerequisites: None. 3 credit hours

SMGT 546 - PROJECT MANAGEMENT: This course introduces students to all areas of Project Management beginning with the definition of a project itself. A variety of learning techniques is used to include case studies, exercises and lectures. The course provides conceptual material on project management techniques appropriate in systems/subsystems management. Topics include project management functions, project management roles and responsibilities; effective teams, the project life cycle; conflict resolution; project planning, budgeting, scheduling and control techniques and cost estimating. Project management is at the heart of DoD acquisition. The goal of this course is to provide the student with the background knowledge and basic tools to handle a project or contribute effectively as a project team member. Prerequisites: None. 3 credit hours

SMGT 641 - SYSTEM ENGINEERING MANAGEMENT: Department of Defense and Air Force program managers are responsible for the development and acquisition of increasingly complex weapon systems. Due to this increasing complexity, program managers are faced with the difficult challenge of fielding systems which meet the user's needs in terms of performance, quality, and cost effectiveness over the entire system life cycle. In order to successfully meet this challenge, a "systems approach," consisting of early planning and comprehensive requirements definition, must be implemented. The discipline of systems engineering provides such a process for bringing a system into being. The purpose of this course is to introduce Air Force acquisition managers to the system engineering process and provide a

survey of various system engineering concepts and techniques. Although acquisition managers will not perform system engineering tasks, they are typically responsible for the management of the system engineering process. Therefore, acquisition managers must understand the multitude of system engineering processes and their theory and application. This course will explore the system engineering processes and functions that ensure all needed engineering disciplines and related specialties are properly considered and integrated into system design. System engineering concepts such as reliability, maintainability, system safety, producibility, and life cycle costs will be examined in depth and students will be required to apply these concepts to real-world systems. Prerequisites: MATH 526/536, OPER 502 and SMGT 646. Winter Quarter
3 credit hours

SMGT 647 - ACQUISITION STRATEGY: The success of a defense acquisition program is frequently contingent on the development and execution of a viable acquisition strategy. This course addresses the policies governing the formulation and execution of acquisition strategies. Particular emphasis is placed on the evaluation of alternative strategies based on the advantages, disadvantages and risks associated with each. Specifically, this course addresses alternative strategies associated with technology insertion, competition, contracting, supportability, production and environmental protection. All students will participate in the development of a comprehensive acquisition strategy through an in-depth case study which is based on an actual acquisition program. Ultimately, this course prepares students to evaluate, formulate and implement acquisition strategies for defense acquisition programs. Prerequisites: SMGT 643 or CMGT 520 or CMGT 523 or permission of course director. Fall Quarter
3 credit hours

SMGT 650 - SOFTWARE SYSTEMS MANAGEMENT: This course covers the topic of software management as it applies to weapon systems and information systems which includes computer software as a key component. This course will discuss the management of custom software acquisition and support from the "buyer-seller" model. Topics discussed include the software life cycle, contracting, product assurance, estimation and measurement, personnel management issues, and security and safety. Examples for the Department of Defense (DoD) environment are included. A case study or paper will enable students to apply the material taught in class. Prerequisites: None.
3 credit hours

SMGT 667 - SYSTEMS MANAGEMENT COLLOQUIUM: The purpose of this course is two-fold: (a) to keep students updated on current issues in systems and contracting management; and (b) to provide a forum for students to interchange ideas on their research efforts. The course achieves the first objective by providing the student with topical presentations from experts in the DoD acquisition community. Class meetings are called when the need arises, and are structured to match the needs of the guest speaker or colloquium leader. The course achieves the second objective by meeting in the Winter and Summer

Terms and having the GSM and GCM students update their peers on their theses. In the Winter Quarter, students provide preliminary proposals and expose their fellow students to literature in their research area and describe the methodology they intend to use. In the Summer Quarter, the students present the results of their theses. This allows all the students to discuss topical issues and add depth to their graduate program. Prerequisites: None. 0 credit hours

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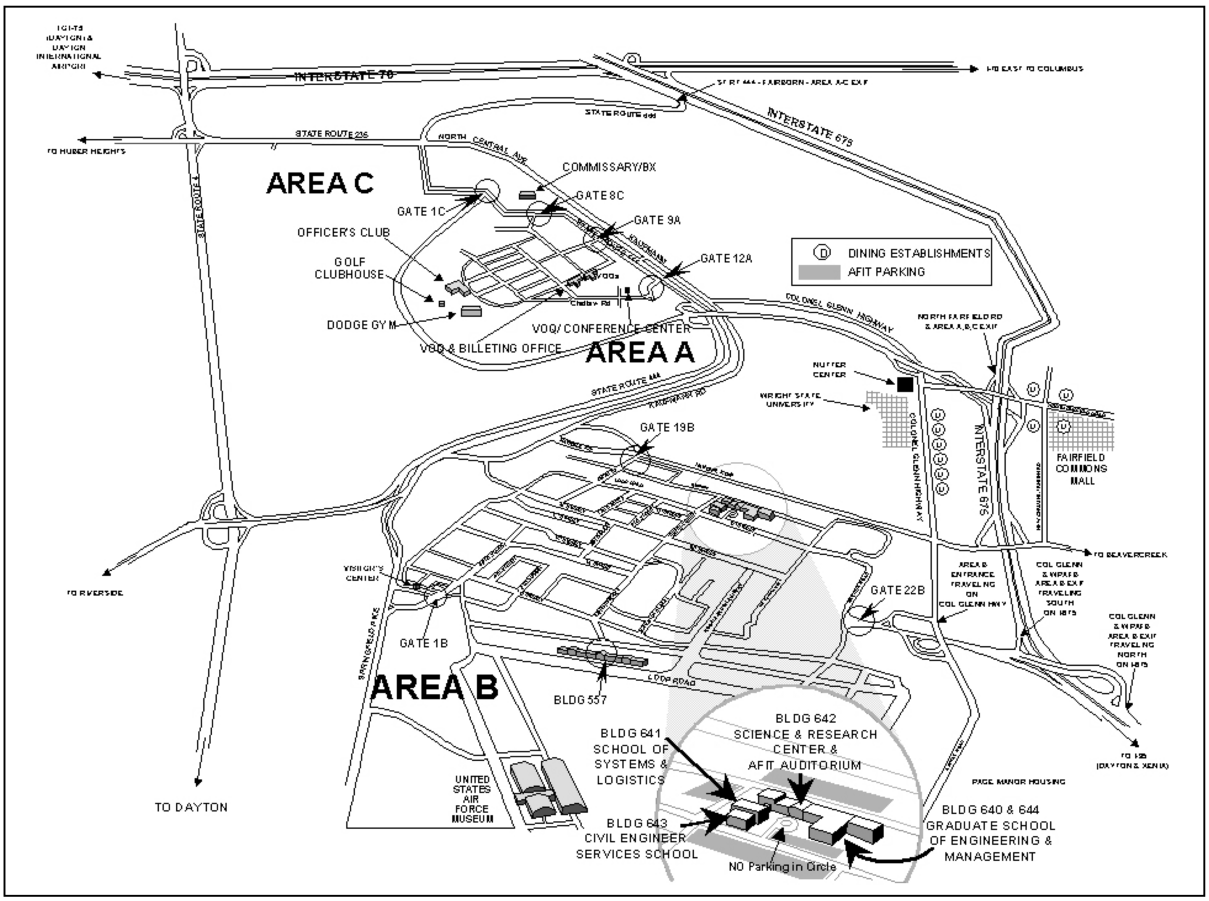
9 MAP AND DIRECTIONS TO CAMPUS



DIRECTIONS TO CAMPUS

Directions from

- **FROM THE AIRPORT AND POINTS WEST:** Take I-70 East and exit at SR 4 South (exit 41A) Travel to Harshman Rd South. At the end of the ramp turn left. Exit at Springfield Pike. The entrance to the base is the next right after the Air Force Museum. Keep in the left lanes, go past the guard gate to the visitor's center (on the right) to obtain a visitors pass. After obtaining a pass, you will have to loop back around to the gate by turning left on Springfield Pike and taking the next left. Go through the gate and turn right on C Street. Continue on C Street and turn left on 10th Street. Continue up the hill to the stop sign (P/Loop St). The AFIT campus is across the street on your right.
- **FROM CINCINNATI AND POINTS SOUTH:** Take I-75 North and exit at SR 4 North. Travel to Harshman Rd South. Continue on Harshman and exit at Springfield Pike (follow the brown sign for the Air Force Museum). The entrance to the base is the next right after the Air Force Museum. Keep in the left lanes, go past the guard gate to the visitors center (on the right) to obtain a visitors pass. After obtaining a pass, you will have to loop back around to the gate by turning left on Springfield Pike and taking the next left. Go through the gate and turn right on C Street. Continue on C Street and turn left on 10th Street. Continue up the hill to the stop sign (P/Loop St). The AFIT campus is across the street on your right.
- **FROM COLUMBUS AND POINTS EAST:** Take I-70 West and exit at I-675 South (exit 44A). Travel to Exit 15 (Col. Glenn Hwy). As you exit, stay in the right-hand lane. At the end of the exit, turn right at the traffic light (Col. Glenn Highway). Travel to the third traffic light (Harshman Road/Wright Brothers Parkway) and turn right. Exit at Springfield Pike; turn right at the end of the exit ramp. The entrance to the base is the next right after the Air Force Museum. Keep in the left lanes, go past the guard gate to the visitors center (on the right) to obtain a visitors pass. After obtaining a pass, you will have to loop back around to the gate by turning left on Springfield Pike and taking the next left. Go through the gate and turn right on C Street. Continue on C Street and turn left on 10th Street. Continue up the hill to the stop sign (P/Loop St). The AFIT campus is across the street on your right.
- **FROM POINTS NORTH:** From I-75 South, exit at I-70 East (exit 61A). Travel to SR 4 South (exit 41A). Continue on SR 4 to the Harshman Rd South exit (follow the brown signs for the Air Force Museum). At the end of the ramp turn left. Exit at Springfield Pike. The entrance to the base is the next right after the Air Force Museum. Keep in the left lanes, go past the guard gate to the visitors center (on the right) to obtain a visitors pass. After obtaining a pass, you will have to loop back around to the gate by turning left on Springfield Pike and taking the next left. Go through the gate and turn right on C Street. Continue on C Street and turn left on 10th Street. Continue up the hill to the stop sign (P/Loop St). The AFIT campus is across the street on your right.